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EXHIBITING A VIEW OF THE

PROGRESSIVE DISCOVERIES AND IMPROVEMENTS

IN THE

SCIENCES AND THE ARTS.

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THE
EDINBURGH NEW
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On the Tribual Government of the Ruder Nations. By LOUIS K. DAA, of Christiania.

The object of the following remarks is twofold.

1. Certain facts connected with the tribual organization of the ruder varieties of mankind will be shown to be much more general than is usually supposed.

2. Certain inferences will be drawn from their existence explanatory of some of the more remarkable phenomena connected with the great diversity of language and tribe within the narrow limits of a small population.

The system under notice is, perhaps, found at its *maximum* amongst the North American Indians; amongst whom we find—

First, The division into tribes or clans.

Secondly, The habit of each tribe having a sort of armorial bearing called the Totem.

Thirdly, The regulation that no man shall marry within his own clan, *i.e.* with a female of the same totem.

It is sufficiently obvious, that in these three facts we have elements of no small importance in the natural history of the savage state.

The form which these institutions take in America is shown by the following extract from Gallatin, in his Synopsis of the Indian Tribes. The italics are the present writer's.

" They will hardly submit to any restraints ; and it is well known that the nominal title of chief confers but little power, either in war or peace, on their leader, whose precarious authority depends almost entirely on their personal talents and energy. Yet we find the nominal dignity of Chief, Sachem, Mingo, or King, to have been, with but few exceptions, amongst all the Indians, not only for life, but hereditary. But another institution, belonging to all the southern, and of which traces may be found amongst the northern nations, deserves particular consideration.

"Independent of political or geographical position, the division into families or clans has been established from time immemorial; but at what time, and in what manner, the division was first made, is not known. At present, or till very lately, every nation was divided into a number of clans, varying in the several nations from three to eight or ten, the members of which were respectively dispersed indiscriminately throughout the whole nation. It has been fully ascertained, that the inviolable regulations by which those clans were perpetuated amongst the southern nations were, first, that *no man should marry in his own clan; secondly, that every child belongs to his or her mother's clan.* Among the Choctaws there are two great divisions, each of which is subdivided into four clans; and no man can marry in any of the four divisions belonging to his division. The restriction amongst the Cherokees, the Creeks, and the Natches, does not extend beyond the clan to which the man belongs.

"There are sufficient proofs that this division into clans, commonly called tribes, exists amongst almost all the other Indian nations. But it is not so clear that they are subject to the same regulations which prevail among the southern Indians."

Having produced the testimonies of Charlevoix, Johnston, and Heckewelder, for the tribual divisions of the Algonkin and Iroquois nations, he continues: "Whether the *Totem*, or family name of the Chippeways, descends in a regular manner, or is arbitrarily imposed by the father, has not been clearly explained. But Dr James informs us, that no man is allowed to change his *Totem;* that it descends to all the children a man may have; and that the restraint upon intermarriage, which it imposes, is scrupulously regarded. They profess to consider it highly criminal for a man to marry a woman whose *Totem* is the same as his own; and they relate instances where young men, for a violation of this rule, have been put to death by their own nearest relations." (Tanner's Narrative, p. 313.) But the Chippeways and kindred tribes are in this manner much more subdivided than the other Indians into clans. Dr James gives a catalogue of eighteen Totems, and says that many more might be enumerated.

"The most direct testimony we have of the similarity of the institution amongst the northern and southern Indians is that of Loskiel, in his history of the Moravian Mission (Part i. ch. v.) 'The Delawares and Iroquois never marry near relations. According to their own account, the Indian nations were divided into tribes for no other purpose than that no one might ever, either through temptation or mistake, marry a near relation, which at present is scarcely possible, for whoever intends to marry must take a person of a different tribe.'

"That a similar division existed amongst the Sioux tribes had escaped former observers. But Dr Shaw, who resided several weeks amongst the Omahaws, informs us, that they are divided into two great tribes, &c. Dr Say in another place says, that even a very remote degree of consanguinity is an insuperable barrier to the marriage union."

We need not repeat Mr Gallatin's observations on the great influence of this institution in regulating the wars and settling the disputes of the different nations. Although his attention has been principally fixed upon the beneficial results of the system, and the peculiar sort of federal government it easily introduces, the tribes mutually preserving an hereditary rank, yet he gives proof that the general tendency of this practice was far from promoting tranquillity and peace.

"The Indians who cultivate the soil are perpetually exposed to the attacks of the wandering tribes. Those of the Missouri had also for enemies the *Sauks* and *Foxes*, who have acted too much in that quarter the same part as the *Five Nations* on theirs; but they had also continual quarrels, often degenerating into actual hostilities between themselves. These originated in encroachments on hunting grounds, elopement, or carrying off of women, and stealing of horses. The enemies wounded in battle are killed on the spot. The prisoners carried home are neither tortured nor put to death. The women are made slaves; the men are considered as servants, and generally employed in taking care of the horses, and in other menial offices, but not in raising corn, that being women's work. The children are almost always adopted into the nation."—P. 130.

Mr Castrén, without being aware of the existence of this institution amongst the Americans, has amply proved that exactly the same laws of tribual government and of marriage originally belonged to all the *Finnic* nations, and that they still continue in force amongst the uncultivated tribes of Siberia.

In his lectures on Finnic Mythology he especially investigates the origin and the conjectures that have been started as to the signification of the lately discovered epic of Finland, the Kalevala. This poem, which evidently is very old, or at any rate describes a state of things anterior to the introduction of Christianity, and which continually carries the reader into the misty regions of witchcraft and Shamanism, has been held by its many patriotic admirers to be a profound allegory, according to the example set by German scholars in expounding the Eddas, Vedas, and the classical mythology. Mr Castrén's opinion on this Iliad of the Fins, which is unquestionably a very important historical document for the illustration of their original manners, as they were thought and embellished by themselves, runs thus, p. 258:—

"If these songs are considered without prejudice, everybody must, without doubt, be brought to the conviction that they, at least for the greater part, rest upon an historical foundation. This circumstance may be proved of all those cantos that describe the travels of courtship of the three heroes *Wäinamöinen*, *Ilmarinen*, and *Lemminkäinen*, and to this class belong most of those that are found in the *Kalevala*. The contents of by far the greater number of the heroic ballads that still exist among our remoter and nearer tribual relations, the *Ostjaks*, the *Samoyedes*, the *Tartars*, are all similar.

These nations also preserve certain manners and institutions, which clearly illustrate the origin and signification of all such songs. One of these institutions is, that every nation is divided into a greater or smaller number of clans, who always stick closely together, but live in the strictest seclusion from other clans not related to them. Formerly, the relation between the several clans was very hostile, and they made predatory expeditions against each other. Even in later days, it has cost the Russian government a great deal of trouble to keep the savage tribes in awe, and to stop their mutual hostilities. At present, it is certainly not said that they commit the more flagrant acts of violence, yet the old hatred is not quite extinct, but shows itself in some way or other, and prevents the different clans from entering into any closer contact with each other. Only when a matrimonial alliance is to be concluded, they must, with or without their will, enter into reconciliation, because, from time immemorial, the law is still preserved, that no matrimony can be concluded in the same clan ; but it is a general tradition that every young man must, with certain exceptions, seek for his bride in a strange clan. Even now, she is not to be obtained except for a considerable bridal price, which must be paid from the bridegroom to her parents or tutors. Formerly, this price was probably still greater, on account of the violent hostility that existed between the clans ; and it seems even that the hand of the maiden, because of this enmity, was sometimes not to be had at any price. The great difficulties which then lay in the way of matrimonial alliances, often tempted the young man to conquer the hand of the maiden by the strength of his own valour,—a custom that is not yet quite out of use among the savage or half savage nations of Siberia. It is exactly this subject that is treated in most of the heroic ballads of these nations, and the greater part of the cantos of the *Kalevala* are of the same import. Thus it is sung in one of these *Runes*, how the brave *Lemminkäinen* violently obtained the beautiful maiden of *Saari*, *Kylliki*. In another canto, the younger daughter of *Pohjola* is carried off by *Ilmarinen*," &c. &c.

" There are also found in the *Kalevala* several other proofs that a courtship by the ancient Fins was connected with great expense and many adventures. The reason cannot have been any other than that this custom also prevailed among our ancestors (the Fins of the Grand Duchy of Finland), never to take a wife from your own, but always from a strange clan, to which you generally stood in an inimical relation."

In *Castrén's Reise-Erinnerungen aus den Jahren* 1838–44, further accounts are given of the effects and the prevalence of this custom, p. 278 "The husband, among the *Zyrjanes*, lays upon the shoulders of his wife every thing that he ought to carry himself, and treats his consort like a slave. The small consideration of the *Zyrjanes* for women is also shown in the mutual relation in which the bridegroom and the bride, even at the nuptials, entertain to each other. Here the bride must, in the presence of all the guests, sing a song, in which she asks the bridegroom, with tears and bows, to feel compassion with her defenceless position, and consider her as his legitimate wife. Of course it is thereby expressed that she is to consider herself as a humble servant. For the same reason, the bride must, after the wedding, undress her consort. In a *Zyrjane's* marriage, also, other customs are practised that show the oppression and deep degradation of woman. Instead of them I will give some of the songs that are sung by the bride and her maids at the nuptials."

These poems, which are translated by Mr Castrén, describe, in forcible language, and with no small amount of poetical naïveté, the bride's feelings of misery on quitting a free life among loving parents for the drudgery and abject position in a strange house, her doleful lamentations being such as might, with the greatest propriety, be employed by a person that is sold or carried off into actual slavery. She even upbraids her brothers that they did not defend her from this misfortune, and asks her parents if she has deserved it by any act of disobedience to them.

And yet the *Zyrjanes*, being converted to Christianity, living in Europe, and interspersed with Russians, whose habits and way of living they have adopted, must be considered as the Finnic tribe that, next to the nations at the Baltic, have assimilated themselves most to European manners. The *Zyr-*

janes also treat their northern neighbours, the *Samoyedes*, as savages, and successfully encroach upon them by the superiority of their half civilization.

P. 286.—"Like the Samoyedes, the Ostjaks are divided into a great number of small clans, each of which forms a small state, or rather a large family. Among the Ostjaks who have adopted Christianity, this division has already ceased, because they are governed by Russian magistrates, and according to Russian laws. Only the Obdorskian Ostjaks still keep up this patriarchal institution which preserves the people in concord and peace, keeps up morality, and prevents many crimes. The power which, in such a community, conducts to virtue, is the love of the whole clan. Every clan consists of a number of families, who have a common origin, and consider themselves as mutually more or less related. There are among the Ostjaks, and especially among the Samoyedes, such clans consisting of several hundreds, or even thousands of individuals, among whom the majority is no longer able to prove their original relation; yet they consider themselves as kindred, enter into no marriages with each other, and consider it a duty to render mutual assistance. Generally those families which are of the same clan keep close together on their nomadic expeditions; and a common practice obtains, that in such a community of families, the rich is to divide his property with the poor. It is evident that in a society thus constituted, disputes must be of rare occurrence. Yet every clan has its elder, whose duty it is to preserve order and harmony in the clan. If two persons belonging to the same clan get into a quarrel that cannot be settled amicably, the case is brought before the elder, who directly gives his judgment without any legal formality. With this result the parties are generally satisfied; if not, the case may be brought up to the Appellate Court, that is the Prince. A number of clans, living near together, from time immemorial acknowledge a common chief, who has the title of a prince. The principal duty of the prince is to preserve harmony among the different clans, and to settle the disputes arising amongst individuals of different clans about their grounds of pasture, fishing, hunting, &c. The elders are subordinate to him."

P. 297.—" As among the Samoyedes, so among the Ostjaks, the wife is a servant in the strictest signification of the word. Yet this is not enough; she is also considered as an unclean being, and lives in the deepest degradation. Her wishes, if she dare to have such, are never expressed when her heart is given away to the highest bidder by her father, her brother, or any other relative. She is treated as an article of trade. To be sure she is not offered for sale at markets, yet it is the highest bidding that settles her future fate. The price of a young girl is different in different districts. In Obdorsk the daughter of a rich man is sold for fifty or a hundred reindeer; a poor man sells his child for twenty or twenty-five reindeer. The cause why the daughter of the rich man is more valuable than that of the poor one is said to be that the future husband expects to receive assistance and support from his father-in-law, not to mention the greater marriage-portion which the daughter receives immediately. Yet the bridal price is not considered as a deposit that is afterwards to be returned, but in fact as a payment for received goods. Nothing is more just, according to the ideas of the Ostjaks, than that the father or guardian of the girl should receive such payment. The daughters are given away at an age when they are fit for work, and only to a complete stranger. But how could the unknown stranger expect that anybody should bring up and support a woman that is to be for her whole life afterwards his slave or servant? The father might retain the daughter in his own house, and then she might, by the work of her mature years, repay the costs of her childhood. In case of the death of the bride before the marriage is consummated, the bridal price is paid back, or the bridegroom receives another daughter. Polygamy is allowed, but of rare occurrence.

" The low state of women among the Ostjaks and other savage nations of Siberia shows itself also in this, that a woman never receives an inheritance. The husband inherits nothing by his wife, and the widow receives nothing after the death of her husband."

Again, the Votjaks in Russia still keep up this clannish system tolerably perfect. (Latham (from Müller), *Native Races of Russia*, p. 55.)

It is evident that this division into clans, and the singular law of marriage connected with it, must exert such an influence upon the whole state of a savage community that it deserves to be regarded as a fundamental law. Whether this enactment be a result of a certain state of manners, or is to be considered as the cause that has produced them, may be doubtful, as is the case with all investigations into human actions and opinions. At any rate, the effects of these institutions must be most powerful in keeping up and preserving every peculiarity which the savage appreciates as a benefit, or makes his boast and glory. It explains circumstances which have appeared incomprehensible to those observers who have merely compared them with the opinions of civilized nations.

1. It is evident that, according to this state of things, the drudgery and the slavery of married women among the savages of Siberia and North America is as natural, and as strictly legal, as the slavery of the negroes in the plantations of the same western continent: the wife of the free savage is a chattel quite as much as the negro of the independent democrat; they are both either bought at a fair price or made prisoners in war. She is a stranger in the house where she serves, as well as the black man is among the whites.

2. Both Castrén and Gallatin admit, although not without self-contradictions, that these enactments must be an everlasting cause of war and hostilities amongst the tribes and clans. The young warrior of course considers it much more chivalrous to take a bride by force than to buy her as a chattel. The old father has lost the recollection of the code of honour according to which he perhaps acted himself when he was young. Hence the abduction is taken up as an insult, that is to be avenged by murder, pillage, and burning, and for these acts, again, there is to be had retaliation (the exact numbers, in making up every account, always being neglected).

3. These wars of course will lead to an endless transformation of clans into tribes, and of tribes into nations, or rather to an expansion or multiplication of the several communities, on the same principle as when bees separate from the common hive. If a nation consist of a certain number of tribes,

it is possible that one of these may, by repeated injuries of this kind, be driven to secede from the community. Thus the Assiniboins seceded from the Dakotas. They received the nickname *Hoka* (rebels) in commemoration of the event (Gall. *Synopsis*, p. 123). Another clan may be expelled by its brother tribes. In a distant district these exiles must establish their community according to the sacred principle, by subdividing their nation into tribes, or raising its clans into the order of tribes, and forming fresh clans out of their smaller families.

The action of this principle, then, will tend continually to diminish the aggregate number of individuals, or to keep down population, at the same time increasing those rather genealogical than political divisions into which the savages are separated or split up.

Thus we see that the endless subdivision of the Americans into separate nations, with different languages or dialects, is not confined to mountainous parts and secluded valleys, where local circumstances produce a stoppage of communication with neighbours, and thus create a natural diversity of habits, and, in the course of generations, also of language. In America the diversity of speech is quite as great, and the tribes almost as small, on the open prairies and along the navigable rivers. In such localities (*e.g.*, in the broad valley of the Mississippi) the breaking up of clans and tribes must be a result of social causes. The ways in which the diversity has been produced must be the reverse of those means that have been employed in the Old World by founders of the great empires, and by the proselytizing religions, which have tended to make one nationality, and a single language, prevalent over an immense area. These mighty and civilized communities have been formed by amalgamating all the members of the society into one family or clan, and by the keeping up a continual peaceful communication between them. In the life of a savage there never were introduced any such general ideas as could connect and combine, while the contrary process of dispersing was going on continually.

This subdivision into endless varieties of language is not peculiar to America, but obtains quite as much among those

Finnic tribes in the Old World who preserved the same institutions.

The Samoyedes differ so much in language from all their neighbours, that they have, in Klaproth's *Asia Polyglotta,* been considered as a peculiar subdivision of the human race. Castrén's great discovery that they are a Finnic tribe of course is not to be understood thus, that their language should be comprehensible to any other population of Fins. The difference is more remote perhaps than between English and German.

These very Samoyedes are subdivided into five dialects, which are described in Castrén's Grammar. They are so very different in words, terminations, and pronunciation of letters as to form in fact five languages, not easily intelligible to the brother tribes who speak them. Each of their principal dialects, again, is subdivided into several minor discrepancies. Yet all these Samoyedes are only a very small number of wanderers in their immense deserts.

But the same observation is made by observers of the manners of the Fins who are settled as agriculturists in fertile open countries, centuries after their conversion to Christianity, and after they have been for ages subjected to the rule of a strong foreign government, that kept all their clans in peace, and promoted the habits of trade and travelling.

The Estonians, in Estonia and Livonia, are a Finnic nation, numbering about 630,000 individuals, and have existed under such altered circumstances for about six centuries. Their country is, as a sea-border, even more easily accessible than the surrounding Russian territories, which are noted for the uniformity of their population. About the language of these "Estonians" there is an article by a native of the country, Julius Altmann (Erman's *Archiv für Wissenchaftliche Kunde von Rusland,* vol. xiv.) According to this author "the Estonian language is divided into two principal dialects, the Dorpatian and the Revalian: both are again equally subdivided into many sub-dialects or *kirchspielismen* (parish dialects). The harsh enmity that exists between the Estonians and their neighbours the Lets, who have a completely different language and origin, also often prevails in adjoining circles and parishes in Estonia itself. It is subdivided into innumerable communities and localities that do not admit of any friendly intercourse or amalgamation, as if with the desire of preventing communication by the destruction of the unity of language. There are in Estonia closely adjoining districts where idioms are spoken that make the mutual understanding, if not impossible, yet exceedingly difficult. What trouble did it not cost me to understand the dialect of Allatzkiwoi, and when I had succeeded in mastering it, how difficult were not then the dialects of the adjoining Tornea and Dorpat, and how hard to investigate the mode of speech in *Haanhof*, *Rauge*, and *Fellin?* The causes that have occasioned this intentional isolation and breaking up of languages and communities among the Estonians must be deeply hidden in the darkness of remote centuries. Yet they must always prevent the Estonians from enjoying even the dawning of a common literature and nationality."

Castrén's and Gallatin's observations about the clannish institutions formerly prevailing among the petty nations of the North of America, Asia, and Europe, seem, however, quite sufficient to explain any amount of diversity and enmity between the closest neighbours.

4. The singular phenomenon that has puzzled all travellers and grammarians, who have described the language of the American Indians, that women and men had different words for many objects, and pronounce certain letters of the whole language in a different way (Fabricius tells us, that the females in Greenland pronounce *k* in the end of words, as *ng*, and *t* as *n*) is easily accounted for, the two sexes belonging, in fact, to two different clans.

5. No law amongst men was ever introduced that contained an unmixed evil to all those that were subject to its influence, or which did not favour the interests of anybody. That the continual warfare of savages tends eminently to keep down their numbers, has been amply proved by Malthus in his treatise on population. That it is conducive to the welfare of a nation, subsisting merely on the natural productions of the land, that its numbers should not exceed their means of subsistence is philosophically evident enough. Yet it is hardly to be credited, that a deliberate system should be adopted by savages over a great part of the world, that had

no other object than to preserve a remote posterity from starvation. This might be prevented quite as effectually, and in a much more patriotic way, by murdering their neighbours, than by putting obstacles in the way of the multiplication of the tribe itself. The plausible reason, that made this law appear as divine wisdom to the untutored ancestors of mankind, must have been its tendency to prevent a more immediate and personal evil, or to introduce a benefit nearer to the interests of everybody.

This will be found, if we consider that the children of the tribe are brought up naked, and that they continue, in most instances, to spend their whole lives in circumstances that would facilitate the utmost licentiousness amongst the sexes. Many families often sleep together in the same room, or live close together in the same village. To this early development of vice, there was put an effectual stop, when all the young people in the clan were to consider themselves as brothers and sisters, between whom every improper conversation was regarded as incestuous, and punished with death. If the married females further were regarded as a property, belonging to the husband, of course their chastity also was kept under the control of individual dominion or tyranny, powerfully assisted by religious fear.

Thus, it may be admitted, as Castrén and Gallatin remark, that the clannish institution preserves savage society from one vice, dearly purchased at the price of many. It has also been observed by several travellers, that the manners of the Indians on the opposite side of the Rocky Mountains, are completely contrary. The accounts that have now been quoted refer to the hunting tribes along the Atlantic coast, and in the valley of the Mississippi. Concerning the Indians on the coast of the Pacific, in Oregon, Vancouver Island, &c., it is stated by Hales (*Ethnography of the United States' Exploring Expedition*), that the distinction of clans and totems is quite unknown among the Indians of Oregon and California. These tribes are grossly libidinous; their women are not slaves, " but, on the contrary, have much authority and consideration, and their work is in a manner considered as their property; for instance, the roots they dig up and prepare" (p. 207).

But this peculiarity is not confined to America. According to the excellent account given by the old German naturalist, Steller, of his sojourn among the Kamtshadales, with whose manners he became intimately acquainted, they were quite as bad as their opposite neighbours in America. Other Russian travellers describe the inhabitants of the Aleutian Islands much in the same way.

Thus, we see, that these manners are not instinctive faculties, or qualities of all savages, but really civil institutions, adopted by some of them, while a contrary polity is the rule amongst others.

Why this difference? Geography will answer, that the nations of the interior country and the forest are hunters, and that the last mentioned, on both the coasts of the Pacific, are chiefly fishermen. The difference in these two modes of subsistence, both in tempting to war and murder, and in promoting sociable life, seems to be great. The fishing Indians always are collected in great bands, and live in large houses or caves, containing more families than one.

Yet this does not account for the whole difference in morals and manners. The Laps in Norwegian Finmark have always been divided into two different sets, fishermen on the coasts, living in fixed habitations, and herdsmen of reindeer, wandering on the mountainous plateaux. Yet no considerable difference has been observed in their morals. Likewise, the Athabascans and Eskimos in America are more dependent for their subsistence upon the produce of the sea, than that of the land. Yet the manners of these same Eskimos and Athabascans seem to approach most closely to those of the hunting tribes.

However, this exception is not at all general on the Pacific coast. The Russian missionary, Wenjaminow, expressly states that the powerful Kolosh nation is divided into the Raven and Wolf clan, and that a Kolosh never marries a woman of the same clan (Erman, *Archiv.*, v. iii., and ii. p. 492). Mr Marchand also mentions the Bear, Eagle, and Porpoise clans. (*Trans. Amer. Eth. Society*, vol. ii., p. 149.) This statement is corroborated in the more minute account of Holmberg (*Ethnogr. Skizzen von Russ. Amerika*, Helsingfors, 1855). The principal divisions of the Kolosh (or Thlenkith) the Raven and Wolf, are again subdivided into more families, also named after animals. Mr Holmberg mentions five of the first, and six of the second tribe; and each of these again subdivided into local divisions.

This system would eminently facilitate the formation of new nations out of the old, without disturbing the clannish principle in any way.

The institution of tribes and clans yet exists among a great number of nations in every quarter of the globe, and, according to historical evidence, it was still more frequent formerly.

In Australia, we find the very same institutions as in America and Siberia, viz., that each clan has his *kobong*, corresponding to the American totem, as a sort of armorial emblem, and that nobody is to marry a woman of his own family-name (Latham, *Varieties of Man*, p. 237). Also, among the Kaffres of Africa (Latham, *Ethnol. of British Colonies*, p. 81).

In the Journal of the Asiatic Society for 1852, Captain Macpherson states, concerning the *Khonds*, "That intermarriage between persons of the same tribe, however large or scattered, is considered incestuous, and punishable by death."

As the Khonds are a remarkable specimen of the original inhabitants of India, before they were mixed with any conquerors of the Japetian stock, and as they have not been led to change their primitive simple religion and manners, this also proves that the caste system is the result of conquest, and not even in India the oldest social form. But a coincidence still more striking is what Sir John Bowring in the *Athenæum*, 17th November 1855, states, "That this same extraordinary law of intermarriage also is preserved by the 400 millions of the Chinese people."

"The strict laws which prohibit marriage within certain degrees of affinity (they do not, however, interdict it with a deceased wife's sister) contribute to make marriages more prolific, and to produce a healthier race of children. So strong is the objection to the marriage of blood relations, that a man and woman of the same *Sing* or family name cannot lawfully wed."

We see here the American Totem and Australian Kobong under the Chinese name Sing. The effect is exactly the same.

Thus the same law may be traced from Mexico along the whole continent of North America, along the north of all Asia and Europe, and along the eastern coasts of the Pacific, through China, down to Australia and Africa. The circumstance that a custom which evidently was adopted in the darkest age of barbarism should be equally preserved by the few savages that still continue in the primæval simplicity and by the millions of the Chinese empire, having attained almost the very opposite extreme of super-civilization, shows, in a most striking manner, the mummy-like preservation of trivial and arbitrary forms and manners by the Celestials. The same article of Sir John Bowring supplies another quite as striking analogy. After having described the omnivorous habits of the Chinese, who do not even reject the most disgusting food, he continues:—"The only repugnance I have observed in China is to the use of milk, an extraordinary prejudice, especially considering the Tartar influences which have been long predominating in the land, but I never saw or heard of butter, cream, milk, or whey, being introduced at any native Chinese table."

Exactly this same prejudice was observed among the Californian Indians by a gentleman who had been for years in daily connection with them, and it was related to me before he had the slightest idea that it also was a peculiarity of the Chinese, and this unreasonable disgust might involve an interesting connection dating from thousands of years.

This prejudice will seem to be derived from the hunting state, when the only milk to be obtained was that derived from the breast of woman, which it might be considered a sort of cannabalism in an adult person to taste. It is also to be observed that the word for milk and breast (bosom) seems to be the same in many Mongolian languages.

Breast,	Samoyede,	*sudo, suso.*	Milk,	Samoyede,	*süt.*
„	Lapp,	*ćidźe.*	„	Ćeremis,	*śür.*
„	Ostjak,	*esem.*	„	Wogul,	*syrtai, surut.*
„	Lesghian (Ćari),	*chudii.*	„	Ostjak,	*tüti, tjuti-jink,* esem-jink.*
			„	. . (Andi)	*śiu.*
			„	Ćersessian,	*ćeh, śeh, ćchü.*
			„	Turkish,	*süt, sjot, sjut, sut.*

* *Jink* means water.

Breast,	Tungus (Mancu,)	*tungen, oecen.*	Milk,	Tungŭs (Mancu),	*sun.*
,,	Korjak,	*maso*	,,	Jukagir,	*iwi-ci.*
,,	Cukci,	*ca inka.*	,,	Jeniseian,	*süt.*
,,	Mongolian,	*upsü, opsu.*	,,	Mongolian,	*sü.*
,,	Aino,	*do, to.*			
,,	Korea,	*ko, dzani.*		Korea,	*kmis.*
,,	Chinese,	*su.*			
	IN AMERICA.				
,,	Ojibbeway,	*totosh.*		Ojibbeway,	*totosh-abo.**
,,	Greenland,	*sikkik, sakkiek.*	,,	Caddo,	*tsotso.*
			,,	Chocta,	*jushuk chi.*
	IN AUSTRALIA.				
,,	Kowrarega,	*susu.*			

Compare the English *teat*, German *zitze*, Norwegian dialect *tisse*.

This absurd prejudice against the milk of animals has then been kept up by the Chinese during and after their transition to the agricultural state of society. The nomadic state they never went through, and the breeding of domestic animals is even now the most neglected part of Chinese husbandry.

A great distinction between the manners of the Celtic nations and the Teutonic, as well as the Slavonic, seems to have consisted in the paramount importance of clan or sept, in ancient Gaul and the British Isles, and the almost total absence of this division in Germany, Scandinavia, and Russia. The influence of this principle upon the formation of large states, or the continuation of a turbulent anarchy, upon the estimation of the female sex, and upon the development of a chivalrous humanity, must here only be alluded to.

What has been remarked may prove the extreme tenacity with which the Mongolian nations preserved the clannish division, even after the formation of great empires; after the development of considerable commerce; and after the adoption of religion having a tendency to promote a common feeling of brotherhood.

It is certain that the tribus or φυλη among the Græco-Roman population was a genealogical, and not a local institution. Of course these divisions were either clans or castes. How they were preserved separate, although forming an integral part of the common state or confederacy, has not been handed down from the darkness of ages, because the Hellenic civilization very soon succeeded in obliterating most of the traces of this institution of barbarism. Yet the Roman history has preserved the following facts, that bear upon this very question.

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* *Abo* means water.

Between some tribes or little nations there existed *connubium*, so that their members might contract a legitimate marriage; between others this connection was unlawful, as in the oldest times between the Patres and Plebeii; marriages were concluded *per coemptionem*, by sale.

When Romulus and his band of lawless *Latin* youths wanted to acquire wives in a more chivalrous fashion, they did not rob them from their own tribe, but from the *Sabines*. This fact is completely Siberian or American. But are we to guess there was a time when the practice of buying or robbing women from a collateral clan was considered obligatory, as well as permitted, among some of the barbarous tribes in Europe?

Unheard of it cannot have been in antiquity, since we find it preserved even to this day by one nation at least, viz., the Albanians or Arnauts, by whom the manners of their barbarous ancestors, the Greek heroes, are kept up in all but the antique and pure originality. Among their manners Hahn (*Albanesische Studien*, 1854) remarks, "That being divided into many clans, intermarriage is prohibited within the same clan (p. 153). The bride is bought by the bridegroom at rather a high price" (p. 180). The concomitants that attend this system among the natives of America and Siberia, internal wars, family feuds, hereditary for generations, are sufficiently known to flourish to perfection both among Christian and Mahomedan Albanese, quite as much among the believers in a heathen Shamanism or witchcraft. Although Mr Hahn denies it, it also seems, from the facts he states, that this peculiar nicety in the selection of wives is perfectly reconcilable with the grossest licentiousness, or may perhaps even produce it by excluding men from the society of women.

The strength of these savage principles is strongly illustrated in this instance, where they have been able to resist for centuries the opposite doctrines of two such powerful religions, the Christian and the Mahometan.

This clannish institution, unnatural as it is, cannot have preserved its sacred character and been kept up as such but with a corresponding care. We have alluded to the horrid systems of initiation, and the peculiar costumes by which the different clans are distinguished.

Among the ways of dressing the hair that distinguish the American Indian is his mode of shaving or cutting all the scalp short, except a tail left in the middle, a practice considerably inconvenient in a variable climate. Yet the arbitrary practice agrees completely with the costume of the Japanese and Chinese in Asia. Among the latter, however, it is a comparatively new absurdity, having been imposed on the nation two hundred years ago by the Mantchou conquerors, because it was their national or clannish badge.

If from the system of clans among the Mongolians we pass over to the castes of the old Japetian nations, we observe in India exactly the contrary law of marriage. Here every man who marries out of his caste loses all his social privileges derived from it. This shows that the castes consider themselves as naturally or originally not only strangers or enemies, but also inferior and superior, as conquerors and vanquished. The nations subject to the totemic system even in their implacable hatred acknowledge the equality of their neighbours.

We find social divisions, founded upon a common origin, existing in the nomades of Arabia, and among all the mountainous countries of Asia. The old history tells us the like among Jews, Egyptians, Greeks, Romans, and Celts. Which of these stood in the same relation of barbarous equality to each other as the Mongolian clans, and which represent superior and inferior grades of society (castes) based upon conquests?

The intimate connection of the clannish institution with the law of intermarriage, and with the regulations of the sexual intercourse, is best shown by the details of the ceremonies and customs by which it is kept up.

The nations, tribes, clans, and families, are distinguished by the totem, or certain marks representing a sort of armorial bearings. Among the more savage and antique tribes these consist not only in a peculiar cut of the dress, the hair, &c., but especially in the different patterns of the tattooing, in horrid mutilations of the body, &c. Thus the Kolosh and Konjag will make one immense or perhaps six smaller holes in the ears, the nose, and the lower lip, and insert in them large pieces of wood, or the teeth of animals, that completely distort the face.

It is expressly stated that these operations are chiefly performed upon young people when they arrive at the marriageable state, and are combined with long and cruel superstitious ceremonies, generally called initiations (Holmberg, p. 21). The effect of these practices will be to impress upon the mind of the young a horrid reverence for this fundamental principle of the savage society and the laws connected with it, also to increase the intimacy of the relations between the members of the tribe that are joined by this community of religious suffering, and implant prejudices and hatred against those that are excluded from the holy community.

It is probable that the origin of circumcision among the African tribes must be viewed in the same light, the more so as its relation to the intercourse of the sexes is more apparent.

On the Animalcules and other Organized Bodies which give a Red Colour to the Sea. By M. Camille Dareste. (Translated from Annales des Sciences Naturelles.) (Continued from vol. iv., p. 287.)

§ VIII. *Colourings produced by Baccillaria.*

These colorations were observed by Captain James Clark Ross, during his celebrated voyage to the Antarctic regions, upon the coast of the new lands which had been discovered a year before by Dumont Durville. Captain Ross' observations were made repeatedly and in different circumstances, some upon the water itself, others upon the ice or snow; but both appeared produced by the same cause. The coloured water was observed by him on 31st December 1842, in lat. 64° S., and long. 55° 28′ W., 30 miles S.E. of the Gulf Mount Erebus and Terror, in a locality where the sea was very deep and much frequented by whales. Captain Ross caused some of the mud to be collected from a depth of 207 to 270 fathoms, and on his return to Europe he sent it to M. Ehrenberg for examination. Its colour was green, and it contained 53 species of microscopic animals, of which the predominant species were Baccillaria, belonging to the genera *Coscinodiscus, Fragilaria,* and *Hemiaulus* (the latter being a new genus). A great number of these animals were still living, and M. Ehrenberg discovered in their interior a kind of green grains which he considered to be eggs, an opinion which has not yet been generally adopted. Those who are engaged in the study of infusoria know perfectly well how, among these animals, the green and red colour pass easily the one into the other.

Coloured ice has been found in still more southern latitudes.

"15th February 1841, in lat. 76° 03′, and long. 166° 12′ E., we perceived several fields of ice; we changed our course southwards in order to avoid them, and as we coasted the shore, we met with a great quantity of brownish-yellow coloured ice. We collected a small quantity of it, and placed it under a powerful microscope, but could not determine the true nature of the colouring matter. Many among us believed that it proceeded from the fine ash from Mount Erebus, which was about eight miles to the south. At 11 P.M. the weather was very calm; we found, in sounding, thirty-eight fathoms, and we collected a greenish clayey mud."

Similar observations of coloured ice were made during the same expedition; on the 17th February 1841, in lat. 76° 35′ S. and long. 165° 21′ W., and the 18th December of the same year in lat. 63° 50′ S. and long. 147° 25′ W. Captain Ross adds that this coloured matter has been found in the stomachs of the Beroes and Salpa, very abundant in these localities.

The water coming from below this ice having been filtered, and the residue sent to M. Ehrenberg, that observer discovered in it a number of microscopic animals. The coloured matter, as in the preceding observation, contained an abundance of the *Coscinodiscus* and *Fragilaria*, and among the latter some *Fragilaria pinnulata*.

§ IX. *Colours produced by Protococcus.*

This colouring matter was observed by M. De Freycinet and M. Turrel upon the coasts of Portugal; and M. Montagne, to whom a bottle of the coloured water was sent, is satisfied that it is produced by a very small microscopic alga, which he refers to the genus *Protococcus*, to which the red snow belongs, and describes under the name of *Protococcus atlanticus*.

"3d June 1845, about 2 P.M., the corvette 'la Créole' was near the coast of Portugal, opposite Cape Spichel, about eleven kilometres from the mouth of the Tagus, and going towards Cape Rocca. There was observed before the ship an isolated colouring in the water of the sea, of a deep red, varying in intensity and shade between brick-red and blood-red. As far as the eye could reach, the sea preserved this tint, although it was not uniform throughout, but exhibited here and there gradations of shade. The places where the water was deeper formed new patches in the middle of the general colouring. Their extent in a north and south direction appeared to be about 150 metres, but their greatest breadth, which was from W.N.W. to E.S.E., could not be attained with certainty by M. De Freycinet. That officer, however, estimated that the phenomenon passed over a field of about eight kilometres or six miles. M. Turrel asserts that he proved the presence of six coloured zones of 400 to 500 metres each, and affirms, moreover, that these bands were prolonged in the direction of the currents produced by the waters of the river, that is to say, from N.W. to S.W., to an extent of about five kilometres. What the estimate may be of the limits of this phenomenon can only be conjectured; at half-past 3, the corvette got beyond *all* intense colour, and great attention was necessary, to observe the faint rosy tint which it still presented."

§ X. *Colour produced by Biphores.*

This fact was observed by MM. Quoy and Gaymard during the voyage of the "Uranie."

"About 100 leagues from the Cape of Good Hope, in lat. 36° S., we saw upon the sea long zones of reddish-brown colour, of which we sometimes could not ascertain the extent. Some at first supposed that it must be fish spawn; but having crossed several of these bands, the net intended to collect sea animals gave us an opportunity of recognising that they were composed of myriads of small *Biphores* from two to three lines in length, living and sailing in company. Their numbers must have been very great to reflect a colour so marked, as their nucleus was not larger than a grain of millet. What surprised us most was seeing, that, in spite of the movement of the waves, they preserved their affinity to each other, so much so that the lines which they formed were perfectly sharp. Another time, the same phenomenon was observed between the Marianne and Sandwich Islands."

It is to be regretted that these two naturalists have not indicated the species of *Biphores* which produced this colour. It is impossible to make them out from the short description which I have quoted.

§ XI. *Colour produced by undetermined animals, but which are probably larvæ of inferior animals or of Infusoria.*

The most complete observation of this kind with which I am acquainted was made by M. Quoy during the first voyage of the "Astrolabe."

"17th December 1828, at 3 o'clock in the evening, being in the sound of the "Bay of Aiguilles," in sight of land, opposite to Algoa Bay, we saw at intervals the sea become brown-red in large spaces and in zones. On casting a net, we found that this colour was produced by an enormous quantity of small animals, about one or two lines in length, quite white, except the head, on which there was a reddish spot.

"The body of this animal is eel-shaped, flat and pointed at the extremity, where it is furnished with a fin which appeared to us notched. Its middle is traversed by a canal, in which, or rather upon the sides of which, there are white granulations belonging most probably to the organs of generation. The part which belongs to the head is surmounted by a very delicate fringed membranous hood. . . . It is there that the red point is placed, partly surrounded with yellow. These animals being in perpetual motion, from the vibration which they impart to their body, the examination of them becomes difficult; they seem to wish to divest themselves of this hood. They quickly spoil the water which contains them, and in half-an-hour they are dead. Their bodies are then bent into different shapes, the head below; they become opaque, of a dim white, and their organization can no longer be distinguished."

M. Quoy says that he has several times met with these animals, but he does not give the localities. He at first made a genus of them under the name of "*Fretillaria;*" but afterwards, on his return to France, thought he discovered in them the characters of the singular, and still enigmatical animal, which Chamisso has described under the name of *Appendicularia*, and Mertens under that of *Oikopleura Chamissonis.* He adds, however, that these animals may possibly be larvæ. And though we cannot decide from such an incomplete description, this latter opinion of M. Quoy appears very probable. The numerous works which have appeared of late years upon the embryo of molluscs can hardly leave a doubt on this point, because we may very easily recognise in M. Quoy's description the hood of the embryo of *Branchiferous gasteropodes* (*Opisthobranches* and *Prosobranches* in M. Milne-Edward's classification), or of the shell-bearing Pteropodes. Unfortunately we can go no further, or determine in a more exact manner the genus to which these remarkable larvæ ought to belong.

As for the identity of these larvæ with the *Oicopleura* of Mertens, it appears to us much less certain. Although Mertens' description is very incomplete, it points to a very different animal to that of M. Quoy, which no doubt presents something analogous to the two-lobed hood of the larvæ of Gasteropodes, but is much larger in size (more than 3 centimetres), and differs from it by the singular property which it possesses, of secreting a sufficient quantity of mucus in order to shut itself up entirely. Besides, this animal has only as yet been found in a very different locality from that where it has been noticed by M. Quoy, Behring Straits and the north of the Pacific Ocean. As to its organization, the observations of Mertens, made with the aid of a simple magnifying glass, are much too imperfect to carry any certainty from them.

Analogous phenomena are often mentioned on the coasts of Chili, but appear to be produced by larvæ quite different from the first, or perhaps by *infusoria.*

The first observation is due to two Spanish captains, Don Jorge Juan and Don Antonio d'Ulloa, who, in the last century, had accompanied to Peru the French commission charged with measuring the meridian, composed of Bouguer, Condamine, Joseph Jussieu, and Godin: it was in May 1735.

"Having embarked in the French frigate 'la Délivrance,' and being in lat. 36° 54′, and 2° 24′ east of the island of Santa Maria, half an hour after having observed it we suddenly found ourselves upon a ridge of yellow water; which gave us a great fright, and obliged us to leave the table, where we were at dinner, and run upon deck, more troubled still as there was no time to tack. The frigate was in the middle of this colour, which appeared to be that of a shoal, and extended in length nearly two leagues from N. to S., and in breadth about 600 to 800 fathoms from E. to W. The colour of the water was so yellow, that after having crossed it, and being at a great distance from it, it was still very easy to distinguish it. Not having been able to sound, owing to the lead not being ready; and, fearing that we had got upon a sand-bank, as all believed, and that in certain points there would be very little water, we never dreamt of putting the ship back in order to learn the depth. There were some places where the water was more yellow, appearing as if it were shallower, and others where the yellow water was replaced by the gulf or greenish water. Every chart does not indicate it, and some of the pilots have never seen it, which is very strange, considering that voyages in this direction are so common. This fact ought to be a warning to all navigators to be on their guard when passing this place."

This observation, very curious in many respects, and particularly in having produced such an error in two able sailors, who were also distinguished naturalists, is explained by the observations of Pœppig and Mr Darwin.

Pœppig remarks :—

"12th March, about mid-day, we were not a little surprised by a cry of alarm from the deck, and the immediate command to bring to. The dirty red colour of the sea had made us suppose that we had got upon a shoal, but the lead found no bottom at 130 fathoms. From the top-gallant mast the sea appeared, quite to the horizon, of a dark red colour, more particularly in a current of which the length was estimated at six English miles, and which divided to the right and left, in short lateral branches. Continuing our voyage, we found that the colour changed into a brilliant purple, so much so that the foam in front of the ship was of a rosy-red. It surprised us that this purple band was easily distinguished from the blue of the sea ; a circumstance which we the more easily recognised, as our track made us cross the band, which extended in a north-east direction. The water brought up in a bucket appeared quite transparent, but a faint purple shade was perceived, when some drops were put upon a china plate, and gently moved from side to side in the sunlight. A magnifier showed numerous small red points, visible to the naked eye with great attention, and consisting of infusoria of a spherical form, which did not possess any external organ of locomotion. Their very quick movements were only up and down, and always in a spiral line. The want of a powerful microscope prevented me from pursuing this delicate research ; and all the attempts made to preserve these animals on paper, by the aid of the filtration of a drop of water, failed, because under these circumstances the drop of water seemed to evaporate. They were above all sensible to nitric acid ; a single drop in a glass vessel containing this animated water, terminated almost instantaneously the existence of millions of these little beings. We sailed about four hours, with a rapidity of at least six English miles, across this band, the length of which was about seven miles, before reaching its boundary. Its surface was, consequently, about 168 square miles English measure. And, if we suppose these organized atoms to be distributed in the upper stratum of water to the depth of only six feet, their number must be infinitely beyond all that human reason can conceive. . . . . This phenomenon of the colouring of the water of the sea has already been several times observed in other regions; but it is rare upon the coast of Chili. In the southern part of the Pacific Ocean, near the Equator, particularly in the Gulf of Panama, and even at a short distance from California, it is very frequently presented. Among the very many sailors who trade along the coasts of Chili and Peru, and whom I questioned during two years upon the subject of this phenomenon, there is only one to be found who had observed it, in similar states and nearly at the same time of year, upon the coast of Valdivia."

The observation of Pœppig was made on the 12th March 1827, about lat. 36°, about two degrees below Cape Pilares.

It is very probably the same phenomenon which was observed by Mr Darwin upon the coasts of Chili.

November 14th 1764.

"On the coast of Chile, a few leagues north of Conception, the Beagle one day passed through great bands of muddy water; and again, a degree south of Valparaiso, the same appearance was still more extensive. Although we were nearly fifty miles from the coast, I at first attributed this circumstance to real streams of muddy water brought down by the river Maypo. Mr Sulivan, however, having drawn up some in a glass, thought he distinguished, by the aid of a lens, moving points. The water was slightly stained as if by red dust; and after leaving it for some time quiet, a cloud collected at the bottom. With a lens, of one-fourth of an inch focal distance, small hyaline points could be seen darting about with great rapidity, and frequently exploding. Examined with a much higher power, their shape was found to be oval, and contracted by a ring round the middle, from which line curved little setæ proceeded on all sides, and these were the organs of motion. One end of the body was narrower and more pointed than the other. According to the arrangement of Bory St Vincent, they are animalculæ, belonging to the family of Trichodes. It was, however, very difficult to examine them with care, for almost the instant motion ceased, even while crossing the field of vision, their bodies burst. Sometimes both ends burst at once, sometimes only one, and a quantity of coarse brownish granular matter was ejected, which cohered very slightly. The ring with the setæ sometimes retained its irritability for a little while after the contents of the body had been emptied, and continued a riggling, uneven motion. The animal an instant before bursting expanded to half again its natural size; and the explosion took place about fifteen seconds after the rapid progressive motion had ceased; in a few cases it was preceded for a short interval by a rotatory movement on the longer axis. About two minutes after any number were isolated in a drop of water, they thus perished. The animals move with the narrow apex forwards, by the aid of their vibratory ciliæ, and generally by rapid starts. They are exceedingly minute, and quite invisible to the naked eye, only covering a space equal to the square of the thousandth of an inch. Their numbers were infinite; for the smallest drop of water which I could remove contained very many. In one day we passed through two spaces of water thus stained, one of which alone must have extended over several square miles. What incalculable numbers of these microscopical animals! The colour of the water, as seen at some distance, was like that of a river which has flowed through a red clay district; but under the shade of the vessel's side, it was quite as dark as chocolate. The line where the red and blue water joined was distinctly defined. The weather for some days previously had been calm, and the ocean abounded, to an unusual degree, with living creatures. In Ulloa's voyage an account is given of crossing, in nearly the same latitude, some discoloured water, which was mistaken for a shoal; no soundings were obtained, and I have no doubt, from the description, that this little animalcule was the cause of the alarm."—*Darwin Jour.* III., p. 17-18.

It is very difficult for us to establish here, as we have done from the preceding observations, the true nature of these little animals. Mr Darwin, in the first edition of his voyage, there saw some infusoria of the genus *Trichoda* of Müller, a genus from which Bory de St Vincent has withdrawn a certain number of species, to make the genus *Oxytricha.* There is a species of *Oxytricha* which is coloured red, observed by M. Ehrenberg in the Baltic, and also by M. Dujardin ; but these naturalists did not find it in quantities sufficient to change the colour of the water. May we not believe, however, that these phenomena are produced by the larvæ of *Annelides*, or naked *Pteropodes*, or perhaps also by certain larvæ of *Asteria* or *Holothuria*, which move freely in the ocean, by means of their circles of vibratile cilia ?

The colouring observed by Lesson, from the 26th February to 4th March 1823, in the roads of Callao, lat. 12° 3′ 9″ S., and long. 79° 33′ 45″ W., during the voyage of La Coquille, is probably due to *Infusoria.*

" A phenomenon which appears to occur frequently on the coasts of Peru, is that of the bright red colour of the sea, in patches more or less limited. We were once deceived into bringing to and sounding, taking that for a shoal, which was simply the result of a prodigious quantity of animalcules which coloured the sea a deep red. In order to assure ourselves of their nature, we took some of the water in a place where the sea was of a blood-red tint, and this water put into a glass preserved its natural colour. In examining some drops of this water with a strong lens, we discovered millions of little red points which, like shrimps of extreme tenuity, moved with great quickness. This water filtered left a deposit upon the paper of about 2 centigrams of a red mucous matter, which formed, when drying upon the filter, a pellicle which changed into green. Were these eggs ? Their very quick movements do not allow us to suppose it. Were these allied to zoophytes, or rather to microscopic crustacea ? This is what we must conclude."

Incomplete as this passage may be, the change of colour from red to green, observed among these little beings, leads us to think that they belonged to the class Infusoria, where phenomena of this kind have been frequently observed. It is not possible to go further.

I presume that it is also to some species of infusoria that the observation of Scoresby, the indefatigable explorer of the Arctic regions, refers; but it also is too imperfect to enable us to give a satisfactory explanation of it. It was made on the 10th July 1823, in lat. 71° 15′, and long. 17° 20′ W.

§ XII. *Colours of which the nature is unknown, but which appear to be produced by matter brought down by the Rivers.*

Some similar facts have been repeatedly remarked; but their nature is not yet known, and even their existence is not always proved.

It is from a cause of this kind that the colour of the Yellow Sea, "Hoang-Hai," is supposed to be produced. At least, in all geographical works it is attributed to the mud brought by the Yellow River ("Hoang-Ho" of the Chinese, or "Kara-moran" of the Mongols).

We have neither positive observations upon the colour of the Yellow Sea, nor upon the cause of it. In my first memoir I have advanced the opinion that this colour might be produced by algæ of the genus *Trichodesmium*, founded upon the observation of a shower of sand which fell at Shanghai, and in which were found vegetable remains. The question is at this moment as undecided as ever, because I do not know of any direct observations upon the fact in question. However, I ought here to refer to an opinion given by Dr Macgowan in a memoir published in 1850, with which I was unacquainted at the time my first paper was drawn up.

In this work, Mr Macgowan gives a description of a shower of sand, formed by an imperceptible dust of a yellow colour, which he observed in China. He adds that this phenomenon is very frequent, and that it seems even to be one of the causes of the fertility of the soil, because this sand would assist to separate the stiff soil of the alluvial lands of China. This sand would come from the desert steppes of Northern China, which form the deserts of Gobi or Shamo. Mr Macgowan thinks that it is these showers of sand, which give to the Yellow River, and consequently to the Yellow Sea itself, the colour which geographers attribute to them. I can only mention this opinion here, without pronouncing either for or against it myself. It appears, besides, to agree with what we know of the Yellow River, that it only takes this colour, peculiar to it, after having crossed the Steppes of Mongolia. The Chinese annals relate that the Yellow River having at one time become clear this phenomenon was followed by a famine. If, as Mr Macgowan says, the fertility of the soil is due, in China, to the showers of sand, it is easily explained how the famine and the transparency of the water of the river would be produced at the same time.

The colour of the Gulf of California, or "Mer Vermeille" (Mar Vermeio of the Spaniards, Vermilion Sea of the English), is likewise still an undecided question. In many geographical works it is attributed to the mud carried down by the Rio Colorado. But, for some time, a very different opinion has been announced on this subject. Thus, in "l'Histoire des Navigations aux terres Australès," of the President of Brosses, we find this sentence, the original of which I have never yet been able to find:—"On rapporte que, dans le Golfe de Californie, la mer est couverte de vers rouge."

The coloration of the sea, by substances carried down by the rivers, would still be a hypothetical fact, if it had not been proved to a certain extent by a particular case, although upon a very limited scale. The fact is, besides, very interesting in many respects, therefore I believe it worth relating with some detail.

It is that of a little river in Syria, named *Ibrahim-Nahr*, which flows into the Mediterranean, near the small town of *Djibaïl*, or *Gebel*, at a short distance from Beyrout, and which, in every year, at a certain season, was coloured red, and communicated this colour to the sea to a certain extent.

What is so remarkable in this fact is, that it was known to the ancients, and connected with the worship of the Phœnician god *Adonis*, *Adonaï* or *Thammuz*, of which Biblos, now Gebel, was the principal seat in Syria. There is a very exact notice of it in the following passage of the work of Lucian, "Sur la Deesse de Syrie":—

"There was still another marvel in the neighbourhood of this town, a river which flows from Mount Libanus and falls into the sea. The name given to it is Adonis. Every year

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it becomes bloody, and, after having lost its natural colour, it throws itself into the sea, which becomes red to some extent, thereby intimating to the inhabitants of Biblos the time when they ought to begin their mourning. It is said, in short, that it is in these days that Adonis is wounded on Mount Libanus; that his blood, which flows into the river, changes the colour by mixing with it, and gives it the name of Adonis. This is what the multitude relate; but a man of the country, who appeared to me to speak the truth, explained to me in another way the causes of this phenomenon. 'The river Adonis, oh stranger, traverses the Libanus, a mountain composed of a very red earth. Violent winds, which regularly arise at certain periods, carry into the river this earth, charged with much vermilion; this is what gives to the water that colour of blood, for it is not really blood, as is said; the nature of the soil is the cause of this phenomenon.' This is what the man of Biblos told me."

Lucian is the only author of antiquity who speaks of this fact, though there are in a great many Greek and Latin authors numerous allusions to the worship of Adonis, which, from the Chaldean and the Phœnician, spread by little and little into Greece. But this remarkable coloration of the river takes place in our days as well as in the time of Lucian, having been observed,on the 17th May 1697, by H. Maundrell, and in 1798 by another English traveller, named Browne, but he contents himself with merely mentioning it, without adding any detail.

It would be very interesting to know this colouring matter, which thus seems to be reproduced every year about the same time. Unfortunately, the observations of this phenomenon are much too insufficient to prove, I do not say to inform us completely, but even to put us on the way of solving this question. M. Ehrenberg, who quotes the passage from Lucian in his beautiful "Mémoire sur le vents alizés, les pluies de sang et la poussière metéorique," observes that there are only white or gray calcareous soils in the Libanus, and that consequently, the opinion brought forward by the man of whom Lucian speaks may be unfounded. He thinks that the phenomenon may be produced by a red-coloured meteoric dust, which, driven by the whirlwinds of the Sirocco, falls every year in Syria. He refers on this subject to a very curious passage from the "Liber Regum," where mention is made of a spring suddenly becoming red. I can here only refer to this explanation, without either pronouncing for or against it. I content myself by only remarking that there existed in Syria some soil formed almost entirely of red sand, and that that may account for the opinion of Maundrell, and also the man of whom Lucian speaks.

In concluding this memoir, I think it right to say that I do not pretend to have collected all the facts regarding the colouring of the sea mentioned by navigators, nor even to have enumerated all the localities where similar facts were observed. I have thought it best, under all circumstances, not to pronounce myself upon the causes of these colourings, or at least only to express a very reserved opinion; and I would not have published this memoir if I had not thought that in all scientific questions it is often necessary to collect and compare the results obtained, in order the better to know in what direction we ought to turn our researches. I have, besides, followed here the example of M. Ehrenberg, who, in an admirable series of memoirs on analogous questions, has endeavoured to show the advantage that may be derived by the union of science with historical and bibliographical knowledge.

It is for navigators to complete this work, by collecting, as much as possible, exact records of the circumstances under which these colourings are produced, and the organized beings by which they are caused.

Note upon the Phenomena described by Mariners under the name of the Sea of Milk, and which are occasioned by the presence of Phosphorescent Animalcules.

Having been obliged, in studying the colourings of the sea, to read a great number of narratives of voyages, I have there met with many observations referring to a white colour which gives to the water the appearance of milk; and although I have not made a special study of this question, I may, nevertheless, point out some general consequences which appear to result from the comparison of these particular facts.

These phenomena are very frequent, much more so than red; in fact, there is scarcely a narrative of a voyage which does not make mention of them; and I believe that the number of these observations on record is three times as great as those of red colourings.

It is especially in the intertropical seas that these phenomena are produced; and they appear to be chiefly abundant in the Gulf of Guinea and in the Arabian Gulf, the most part of the observations referring to these two localities. In the latter the phenomenon was known to the ancients more than a century before the Christian era, as may be seen from a curious passage from the geography of Agatharchides: "Along this country (the coast of Arabia) the sea has a white aspect like a river; the cause of this phenomenon is a subject of astonishment to us."

An explanation of the phenomenon may possibly be found in the beautiful experiments upon the phosphorescence of the sea, which have been made at Boulogne in 1850 by M. Quatrefages. This naturalist has discovered that the *Noctilucæ* which produce that phenomenon do not always give out clear and brilliant sparks, but that, under certain circumstances, which he has studied with much care, this light is replaced by a steady clearness, which gives in these animalcules a white colour. We may thus understand how, when these animals are in considerable masses, they may present this steady clearness, and colour the sea white to a great extent. *Noctilucæ* do not appear to be the only animals which possess this property. Thus, in an observation of M. Grafton Chapman, the animalcules, producing the white tint and phosphorescence, were probably gregarious animals, of the genera *Salpa* and *Pyrosoma.*

These white colours, like the red, appear frequently, though I dare not say always, in the same localities. I will only quote one example which has been observed in the neighbourhood of the Cape de Verd islands: it is taken from the narrative of the voyage of the "Vénus," by M. Dupetit-Thouars.

"On the 13th January 1837, at two o'clock, having perceived that the sea had changed colour, we sounded, and did not find a bottom at 300 fathoms. The changed colour of the water did not then seem to be attributable to the quality of the bottom, but more truly to the presence of little animalcules or molluscs, named "*Squid*" by the English. These waters which appear coloured, do not change their place to any sensible degree, in fact in several voyages I have met with them in the same position; but, not wishing to content myself with only quoting what I have met with myself, I will say that in this track we found them in lat. 21° 29′ 39″ N., and long. 21° 45′ 30″ W. of Paris; that Frésier, in his 'Voyage to Chili' in 1712, found them in lat. 21° 21′ N., and long. 21° 39′ W.; and the American Captain Fanning met with them, on the 12th July 1797, in lat. 21° 48′ N., and long. 23° 50′ Greenwich. All these observations go to prove that those coloured waters are limited, and it seems to me that they must be the same as those which were seen in the voyages which we have quoted, since the positions are nearly identical."

An attempt to determine the Average Composition of the Rosedale, Whitby, and Cleveland Ironstones. By W. Crowder, Esq.

Some few months ago I communicated to the *Edinburgh New Philosophical Journal* a paper on the Cleveland Ironstone, in which I endeavoured to show the composition of that district by a series of analyses of the beds, taken in regular sequence from the mines at Hutton Low Cross, near Guisboro. Since that paper was written, I have had occasion to inquire more particularly into the average yield of iron, and general character of this and similar stones, and believing the question to be one of great local, if not national importance, have undertaken a series of analyses which, it is hoped, will suffice to set the matter at rest. In making an examination of the minerals of any district, it frequently happens that the results of experiment differ widely from those obtained in practice. This discordance arises not so much from any defect in the analyses themselves as from want of a sufficient *number* of experiments, to show the fluctuations in composition; for it frequently happens that within a very small compass large masses of ore will yield results which differ materially from each other, so that by adopting any single analysis, very erroneous impressions and mischievous results may be the consequence.

If this view be correct, it will follow that in attempting to arrive at the average composition of any stratified beds, that examination would give the best results, and be nearest the truth, which gave the greatest number of analyses of the mineral taken from the greatest number of places. Minuteness of analysis would here be of secondary value, whilst repetition would be of the highest importance.

In the present communication I have endeavoured to carry out this principle, believing that it is only by a continued repetition of analyses of the beds, under a variety of circumstances, and derived from a number of independent sources, that any general conclusions can be deduced. A large number of specimens about to be noticed have been collected by myself, during a tour through the district a few months ago, whilst the remainder have been derived either from the owners of the mines or from other undoubted sources. The whole have been selected with the greatest care, and it is hoped that the present will form a contribution of some value to our knowledge of the mineral resources of Yorkshire.

Whilst endeavouring to multiply observations, I have not overlooked the value of minute analysis, and have given a complete examination of as many specimens as my time and opportunity have allowed.

The ironstones principally examined are—

1*st*, Those from Rosedale Abbey, about 10 miles from Pickering.

2*d*, Those found in the neighbourhood of Whitby.

3*d*, Those from the Cleveland Hills, which are perhaps the most important deposits.

It will be seen that these three classes of stone differ widely from each other, not only in the chemical constitution of different localities, but at the same place, thus exemplifying at once the necessity for systematic repetition and investigation.

Before proceeding to the subject more immediately under consideration, it will be as well to make some few observations upon the mode in which the following analyses have been conducted.

The silica, lime, and magnesia, were determined in the usual way. Protoxide, and peroxide of iron, were determined in all cases by standard solution of permanganate of potash by the usual method. The strength of the solution was such that 100 graduations oxidized about 5 grains of iron. Alumina was determined by precipitation along with the iron in the filtrate from silica, by deducting the quantity of iron (as obtained by the permanganate process) from the alumina and iron, the quantity of alumina was obtained. If phosphoric acid was present, the quantity of this ingredient was deducted from the alumina.

Sulphur was determined by oxidation with nitric acid and precipitation with nitrate of baryta, and the sulphuric acid determined in a separate portion, and deducted from the total quantity of sulphate of baryta.

Phosphoric acid was determined by one of two methods: *1st* method—After burning off the precipitate of iron and alumina (which contains the phosphoric acid) it was dissolved in hydrochloric acid; tartaric acid, sulphate of magnesia, and ammonia were added, and the phosphoric acid determined. Or: *2nd* method—20 grains were dissolved in hydrochloric acid, and boiled. The fluid, which contains the iron principally as *protoxide*, was treated with an alkaline carbonate in the cold till a precipitate was about to form, acetate of potash was then added, and the fluid boiled. The phosphoric acid comes down with only a small quantity of iron; the remainder of the iron, which is still in the state of protoxide, passes through the filter. After washing the precipitate with boiling water, it is dissolved in hydrochloric acid; tartaric acid, sulphate of magnesia, and ammonia added, and allowed to stand 24 hours.

The precipitate of phosphate of magnesia and ammonia is then dissolved and re-precipitated.

Water was determined by heating 20 grains in a tube, and collecting the water in a chloride of calcium tube.

Carbonic acid was either determined by the usual method (viz., by the loss sustained after adding acid and evolving the gas), or, by fusing 20 grains of the ore with 60 or 80 grains of dry borax, and noting the loss, which consisted of water and carbonic acid. By deducting the water in the preceding experiment, the quantity of carbonic acid is obtained. This method has the advantage of being both rapid and accurate, when a good heat can be obtained. There is, however, a great drawback, which led to the abandonment of the process. I found that the platinum crucibles in which the experiment was conducted were rapidly corroded, losing from 0·50 to 0·70 gr. in weight at each experiment.

In some instances the carbonic acid was determined by loss on the analysis. By careful experiments on several of the Cleveland stones, I found that I was able to rely upon this plan in a large number of instances.

Rosedale Ironstone.—In my former communication I gave the analysis of two or three samples of ironstone from Rosedale, but at that time I was not aware that there were two localities of the same name. Since then I have found that there is a place called Rosedale on the sea-coast, at which a large quantity of iron ore is raised and shipped; and I have now no doubt that the two samples stated to contain 36·82 and 27·93 per cent. metallic iron were obtained from that place, and not from Rosedale Abbey, which is many miles inland. The whole of the present specimens were taken by myself at the mines near Rosedale Abbey about three months ago, and great care was taken in their selection to insure an average result. Much of the stone occurs in large nodular masses, encased in a kind of shell, called scrap by the workmen. It is very variable in composition, depending upon its stage of decomposition.

The outer coverings appear to have originally had the same composition as the inner portion, which is a carbonate of iron—and has, by decomposition, being converted into hydrated peroxide.

There are several places already opened out for working this stone, but the best quality appears at present to be confined entirely to one spot.

It is here obtained by open quarrying into the face of the hill, the thickness of the stone being upwards of 20 feet. Whether this will be lost as the work proceeds remains to be seen; at the present moment it would perhaps be premature to give a decided opinion. The colour of the stone at this place is dark blue, bordering on black, and it occurs in thin slabs, constituting the cases of the inclosed nodule. This blue-black stone is by far tho richest in quality, but there is a great quantity of a light blue colour, occurring more particularly at a drift which has been made in the hill-side near the quarry; this latter is quite different from the blue stone.

There is also, at the crest of another hill about 1 or 2 miles from this place, a drift pushed about 20 feet into the hill-side, where a large quantity of the light blue nodules are found incased in a series of coverings, the analysis of which I have given, to show the gradual changes that have taken place. These nodules and scraps lie embedded in a soft friable matrix of ironstone of brown colour, which constitutes the principal bulk of the ore at that particular locality.

For distinction, I shall call the three different places—

The Quarry, from whence the dark blue stone is obtained.

The Shaft and Drift, from whence the light blue stone is obtained.

The Drift, 2 miles away, from whence light blue and brown stone is obtained.

The Quarry.—Description and analysis of the dark blue stone:—

A. Mass of dark blue-black stone very compact.
B. Do. slightly altered by exposure to the air.
C. Do.
D. Do.
E. Dark blue stone streaked with rust-red layers.
F. Do.
G. Do. altered by exposure to air.
H. Do.
I. Do. with wide streak of rust-red colour.
K. Do. altered by exposure.

The following are the quantities of silica and iron in each stone. I may mention that this is a kind of magnetic iron ore, and appears to contain about equal proportions of protoxide and peroxide of iron:—

	Silica.	Peroxide of iron.	Metallic iron.
A, . .	8·60	61·86	43·30
B, . .	7·75	55·00	38·50
C, . .	8·90	49·65	34·75
D, . .	7·30	56·02	39·21
E, . .	7·15	70·45	49·31
F, . .	8·70	68·77	48·14
G, . .	6·70	57·37	40·15
H, . .	8·55	63·40	44·38
I, . .	6·20	71·12	49·78
K, . .	6·80	62·73	43·91
10 samples, average	7·66	61·63	43·14
Maximum, .	8·90	71·12	49·78
Minimum, .	6·20	55·00	34·75

Annexed is the analysis of an average sample of this stone made in the laboratory by my pupil Mr George Steward. I also append an analysis of a specimen of this substance by my friend Mr John Pattinson, chemist to the Clarence Iron Works, Middlesboro', who kindly communicated the result, and which fully confirms the correctness of the other examination in nearly every particular.

This close agreement is exceedingly interesting, when it is considered that the samples were obtained through entirely different sources, and analyzed independently, without any intention of comparing the results with one another.

Analysis of Two Samples of Rosedale Ironstone, Dark-Blue Magnetic.

	Steward.	Pattinson.
Protoxide of iron, . . .	33·55	33·85
Peroxide of iron, . . .	31·40	32·67
Alumina, ...	16·05	3·15
Lime, ...	2·35	2·86
Magnesia, ...	1·29	1·59
Potash, ...	...	Trace.
Carbonic acid, . . .	10·26	10·36
Silicic acid, ...	4·50	6·95
Sulphuric acid, ...	...	Trace.
Sulphur, ...	...	0·03
Phosphoric acid, ...	...	1·41
Carbonaceous matter, . .	...	0·84
Water, ...	1·34	3·76
Protoxide of manganese, . .	...	0·69
	100·74	98·16
Metallic Iron, . . .	48·07	49·17

The Shaft and Drift near the Quarry.—I have examined several samples of the stone which is obtained from this place. It is of a light-blue colour, and is, when first taken from the mine, both soft and friable. On exposure to the air it becomes red, from conversion into peroxide, and much resembles externally the matrix in which it is embedded.

No. 1. A thin scrap, blue on the inner side, and brown outside.

No. 2. The light-blue nodule inclosed in No. 1.

No. 3. A thick scrap made up of a series of brown layers streaked with thin blue layers.

No. 4. A light-blue nodule inclosed in No. 3.

Analysis.

	Silica.	Peroxide of iron.	Metallic iron.
No. 1, . .	6·70	64·25	44·97
No. 2, . .	7·40	53·89	37·72
No. 3, . .	8·90	50·17	35·11
No. 4, . .	7·85	64·25	44·97

The Drift about two miles from the Quarry.—I spent some time in examining this spot, as the changes that appeared to be going on between the air and the light-blue stone were very marked; and it afforded a good opportunity of studying the manner in which these curious concretions are undergoing alteration.

On minutely examining one of these nodules *in situ,* the first envelope had some similarity in appearance to the mass which it surrounded—that is, it had the appearance of blue and brown stone intermixed.

The next covering had lost all appearance of light-blue, and was reddish-brown.

The outer casing of all was very similar to the preceding.

Each of the specimens were taken separately and analyzed, with the following results:—

Analysis of Section showing the Composition of a Light-Blue Nodule and its surrounding Scraps. By Mr E. C. Northcott.

	A. The Nodule.	B. 1st Scrap.	C. 2d Scrap.	D. Outer Scrap.
Silica, ...	9·65	8·20	10·95	8·20
Protoxide of iron, .	35·25	4·97	1·24	...
Peroxide of iron, .	12·22	50·63	54·65	60·05
Alumina, . .	14·10	18·70	14.22	15·45
Lime, ...	2·38	Trace.	0·48	1·15
Magnesia, . .	3·95	1·41	0·27	0·72
Sulphur, . .	Trace.	Trace.	Trace.	Trace.
Sulphuric acid, .	Trace.	Trace.	Trace.	Trace.
Carbonic acid, .	16·25	Trace.	Trace.	Trace.
Water, ...	4·80	15·50	17·50	15·40
Proto and peroxide equal to	98·60	99·41	99·31	100·97
Metallic iron, . .	35·94	39·30	39·22	42·03

A glance at the quantities of protoxide of iron in these specimens will show the changes that have taken place from a carbonate to a hydrated peroxide of iron.

In order that the quality of this stone should be thoroughly tested, I collected five samples taken one foot apart from top to bottom of the drift. These were tested separately for silica and iron, and equal weights of each sample were mixed together and analyzed. An average valuation of the entire stone was thus obtained, whilst the determination of silica and iron in all the samples exhibits its maximum and minimum quality.

Analysis of Five Samples of Brown Ironstone from the Drift two miles from the Quarry.

	Silica.	Peroxide of iron.	Metallic iron.
A, ...	15·00	50·15	35·10
B, ...	11·50	54·30	38·01
C, ...	11·00	57·05	39·93
D, ...	13·00	51·30	35·91
E, ...	8·70	55·50	38·85
Average, . .	11·84	53·66	37·56
Maximum, . .	15·00	57·05	39·93
Minimum, . .	8·70	50·15	35·10

Analysis of the Average of Equal Parts of the above Five Samples.

Silica,	12·20
Protoxide of iron,	2·50
Peroxide of iron,	51·50
Alumina,	14·50
Lime,	1·95
Magnesia,	1·15
Sulphur,	Trace.
Sulphuric acid,	Trace.
Carbonic acid,	1·70
Water,	11·50
	97·00
Metallic iron,	38·01

It will be seen that this stone is of considerable value, containing, as it does, on an average, about 38 per cent. of metallic iron. It is very free from sulphur, and contains only a very moderate quantity of silica.

There are many other places in this locality where ironstone of good quality may no doubt be obtained, but, my time being limited, I had not the opportunity of more fully exploring the district.

There is still an insuperable objection to working this stone, viz., the want of railway communication. At present the nearest point to the Whitby and Pickering line is at Pickering, ten miles distant, and the conveyance of the stone by carts, in consequence of the great expense of transit, renders its attainment a matter of secondary importance.

Recently some surveys of the district have been made with a view to the projection of a line to the spot, but the contortions of the strata rendering the loss of the seam of stone a matter of possibility, will no doubt make such an undertaking peculiarly hazardous as a monetary speculation.

The Whitby Ironstone Beds.—In proceeding along the sea shore, from Whitby northwards towards Redcar, the rocks forming the coast line contain a number of beds of ironstone varying in composition, but consisting, at the places where I have examined them, either of carbonate of protoxide or hydrated peroxide of iron. The latter, so far as my own observations go, is the most frequently found, but beds of carbonate of iron are obtained of considerable thickness in places.

The stone is obtained by drifting into the cliff, and is conveyed to ships by means of jettys thrown out towards the sea.

I have not had so many opportunities of investigating the locality as could be desired, but have principally confined myself to one or two mines, where a large quantity of this material is obtained.

It is of a dark brown colour, friable, and consists of hydrated peroxide of iron, mixed with variable proportions of sand. Along with the preceding is a stone of much lighter colour and more sandy appearance, and which occurs in considerable quantity. From a letter that I have lately received from the proprietor of one of those mines, I understand that they have come upon a bed of stone, a sample of which I have seen, and which is a carbonate of iron, apparently similar to the stone I shall have to speak of presently, viz., the Sleights Bridge and tunnel stone. The specimens are obtained from the Raithwaite mine, which is the first drift in the cliff after proceeding northwards from Whitby. Part of these were taken by myself, and part have since been sent to me by the proprietors.

It will be seen that the specimens taken by myself are, on the whole, not so favourable as those sent by the parties themselves, but I must in fairness state that I was cautioned at the time I took the samples that I had selected the worst of the stone.

The two collections must therefore be considered as one, and the value of the stone judged of by the average result. I may, however, state that some of the samples that I took were from the waggons on the jetty, which were *of course* about to be unloaded into ships.

The following are the analyses of those samples which were taken by myself from the mine and from the waggons:—

	A	B	C	D	E
Silica, . . .	44·75	68·85	58·15	49·45	32·45
Metallic iron, .	22·09	16·69	22·60	29·72	34·70

Description.

A, . . .	Light-coloured sandy stone.		
B, . . .	Do.	do.	
C, . . .	Snuff-coloured	do.	very rotten.
D, . . .	Do.	do.	do.
E, . . .	Do.	do.	do.

The following are the analyses of those samples sent to me by the proprietors of the Raithwaite mines :—

	1	2*a*	2*b*	3	4	5	6
Silica,	36·35	21·00	37·20	18·35	14·00	12·45	18·00
Metallic iron,	25·69	34·26	32·27	34·09	41·86	45·25	33·60

External Characters.

No. 1, . .	Light-coloured sandy stone.
No. 2*a*, 2*b*, .	Ditto.
No. 3, . .	Dark snuff-colour, with many shells.
Nos. 4 and 5, .	Dark rust-red rotten stone, irregular fracture.

On looking over these analyses, the quantity of silica obtained in the first set will be seen to be very high, compared with what is found in many iron ores in the same neighbourhood, and a careful distinction between the good and bad will have to be made if the material is to maintain a good name among ironmasters.

It would appear that the light-coloured stone is much inferior both in yield of iron and proportion of silica to the dark, and the quality of the dark-coloured stone would become much deteriorated by the admixture of any considerable quantity of the light.

Since the specimens A, B, C, D, and E, were analysed, I have ascertained that the siliceous portion of the stone is thinning out, its place being supplied by that of which 2 *a* and 2 *b* are examples. No. 6, I understand, is about 2 ft. 6 in. in thickness. I have made no average analysis of these stones, as their quality and chemical composition are so variable that it could lead to no useful result; but it may be stated generally, that the best appears to contain from 34 to 45 per cent.

A stone differing much in composition and appearance to those already mentioned occurs in large quantity, and is extensively worked, at a few miles from Whitby.

In proceeding from Whitby, in a south-westerly direction by the Whitby and Pickering Railway, a large number of iron mines are observed. Some of this stone has been worked for years, whilst in other cases the drifts have only lately been opened. I have reason to believe that the seams found at

Raithwaite mines are also to be found extensively here, but my object is more especially to illustrate the composition of that stone which appears here, and does not often occur on the sea-shore. It is much more uniform in composition than the preceding, and I understand is obtainable in very large quantities.

The locality has the great advantage of railway communication, in fact the railway passes completely through the district, and sidings run direct from the main line to the mouths of the mines. The stone occurs as far as Grossmont, which is about the fourth station down the line.

I have selected the stone from two places, and append analyses of that found at Sleights Bridge and at the tunnel.

The following are the quantities of iron and silica;—

Analysis of Sleights Bridge Stone.

	Silica.	Peroxide of Iron.	Metallic Iron.
A, ...	10·00	41·20	28·84
B, ...	9·00	43·55	30·48
C, ...	8·50	42·20	29·54
D, ...	11·60	43·55	30·48
Average, . .	9·80	42·62	29·83
Maximum, . .	11·60	43·55	30·48
Minimum, . .	8·50	41·20	28·84

Sleights Bridge Ironstone.—Analysis of Equal Weights of the preceding Stones.

Silica, ...	9·35
Protoxide of iron, ...	38·56
Peroxide of iron, ...	Trace.
Alumina, ...	12·15
Lime, ...	4·85
Magnesia, ...	4·40
Sulphur, ...	Trace.
Sulphuric acid, ...	Trace.
Carbonic acid, ...	28 00
Water, ...	2·50
Peroxide equal to	99·81
Metallic iron, ...	29·90

The following are the determinations of silica and iron in the stones from the tunnel :—

Analysis of Tunnel Stone.

	Silica.	Peroxide of Iron.	Metallic Iron.
A, ...	15·70	36·75	25·72
B, ...	12·20	45·50	31·85
C, ...	15·50	45·15	31·60
D, ...	17·00	36·05	25·23
Average, . . .	15·10	40·86	28·60
Maximum, . . .	17·00	45·50	31·85
Minimum, . . .	12·20	36·05	25·23

Tunnel Stone.—Analysis of Mixture of Equal Weights of the preceding.

Silica, ...	15·00
Protoxide of iron, ...	35·55
Peroxide of iron, ...	1·80
Alumina, ...	12·30
Lime, ...	5·35
Magnesia, ...	2·10
Water, ...	2·30
Carbonic acid, ...	27·00
Protoxide and peroxide equal to . . .	101·40
Metallic iron, ...	28·91

This stone, in appearance and composition, seems to be the same as that found in the Cleveland Hills, in fact I believe it is considered (geologically) identical. The colour, hardness, and presence of the little oolitic concretions would immediately strike an unpractised eye, and the chemical composition leaves no doubt that this is the same bed of ironstone.

Cleveland Ironstone.—I have been induced to enter into an extended and minute examination of this stone, from the great importance of an exact knowledge of its chemical composition, it being now so extensively smelted in the district where it is raised.

In Cleveland its yield of iron has been a matter of some discussion, whilst the iron made from this stone alone is said to be somewhat inferior in quality, requiring the use of Cumberland hæmatite, in variable quantities, to impart strength, tenacity, and fluidity.

The proportion of iron has generally been judged of by the quantity obtained in the smelting operations; but it will be evident that this, although the best test in the hands of a skilful manufacturer, would be most fallacious in the hands of an indifferent operator.

In conjunction with the present investigation, I have therefore instituted an inquiry into the chemical composition of the slags of the blast furnaces and the iron produced simultaneously. The results of these experiments will shortly be published, and I shall then have occasion to direct attention to a number of singular circumstances connected with the slag and corresponding iron produced.

The principal mines whence this stone is obtained are those of Eston, Hutton Low Cross, Normanby, and Upleatham. There are other places besides the above named, but I have preferred to analyse these minutely rather than examine a number of places superficially.

In the analysis of the Cleveland stones previously published, I did not determine the quantity of water and carbonic acid separately, and in most instances the phosphoric and sulphuric acid were omitted, whilst I contented myself by stating the iron to be equal to so much peroxide. In the present instance I have, in nearly all cases, determined every constituent separately. The carbonic acid forms the only exception. This latter has, in most instances, been determined by loss on the analysis. It was, however, performed in a sufficient number of cases to establish the correctness of the method, as may be seen by referring to *E* and *F* in the Hutton, *A* and *B* in the Upleatham, and in the Normanby stone analyses.

This stone is exceedingly free from sulphur; in nearly all cases little more than traces can be detected; but phosphoric acid seems to be almost invariably present in considerable quantity.

It will be observed that the stone is a carbonate of protoxide of iron; but there is always a small quantity of peroxide present, generally about 2 or 3 per cent. The stone varies very much in general appearance; but the characters of each bed are so distinct that the different varieties may be recognised without difficulty. Some of the specimens taken from one mine, when compared with those from another, appear so similar as almost to belong to the same piece.

The following are the analyses of the mines enumerated:—

Eston Nab Main Seam.—This seam is from 12 to 17 feet in thickness; solid; not divided by any seam or band of other matter, if the samples marked A to F are taken from a section of the seam,—A being the top of the seam and F the lowest part, and the letters intermediate in the order of their sequence.

G is from a part of the mines where the ironstone is abundantly filled with marine shells, which is not the case everywhere. It will be seen that this stone (G) contained a much smaller percentage of iron and larger percentage of lime than any of the others, which may be accounted for by the proportion of shells in the specimen.

Analysis of Ironstone from Eston Nab (main seam).

	A.	B.	C.	D.	E.	F.	G.
Silica, ...	10·90	11·95	6·00	7.65	7·55	19·90	1 95
Peroxide of iron, .	3·55	6·73	3·95	1·20	...	1·55	2·45
Protoxide of iron, .	39·01	39·05	40·85	43·35	41·22	39·50	24·93
Alumina, ...	10·62	13·83	12·66	9·88	14·28	17 87	12·72
Lime, ...	1·70	2·52	traces	0·58	trace	1·56	8.56
Magnesia, ...	3.19	2·72	3·19	5·35	5·48	2·31	1·80
Sulphur, ...	trace	trace	trace	0·09	trace	0·13	0·10
Phosphoric acid, .	2.08	1·02	2·49	3·87	1·02	2·50	1·88
Carbonic acid, . .	25·26	16·38	26·16	22·96	25·32	5·54	41·54
Water, ...	3·69	5·80	4·70	5·07	5·13	9.14	9·07
Proto & Peroxide eq. to	100·	100·	100·	100.	100·	100·	100·
Metallic iron, . .	32·83	35·10	34·54	34·54	32·06	28·73	21·10

	Phosphoric acid.	Silica.	Metallic iron.
Average, ...	2·39	11·98	31·27
Maximum, ...	3·87	19·95	35·10
Minimum, ...	1·02	6·00	21·10

External characters of the stone:

A, cinnamon coloured stone, made up of oolitic grains.
B, C, blue green-stone, full of oolitic grains.
D, the same, but *dark* blue-green colour.
E, the same, but still darker colour.
F, hard compact stone; olive-green colour; no fossils.
G, dirty-green colour; highly fossiliferous.

Analysis of the Stone from Hutton Low Cross.

	A.	B.	C.	D.	E.	F.	G.	H.	I.
Silica, . .	20·90	12·80	16·55	15·65	13·00	7·20	12·60	10·40	15·65
Protoxide of iron,	35·55	40·36	37·41	35·75	38·39	40·86			
Peroxide of iron,	1·70	2·41	...	1·80	5·16	4·25			
Alumina, . .	3·79	3·71	9·86	4·95	3·79	3·44			
Lime, . .	4·20	2·70	3·08	7·39	3·00	3·80			
Magnesia, .	1·12	0·49	trace	2·98	4·80	3·70			
Phosphoric acid,	2·66	1·92	0·67	5·05	2·01	0·96			
Carbonic acid, .	25·18	32·72	26·32	23·47	28·40	32·50			
Sulphur, . .	trace	trace	trace	trace	0·05	1·60			
Sulphuric acid, .	trace	0·31	trace	0·07	0·02	0·30			
Water, . .	4·90	2·58	6·11	4·89	1·45	1·45			
Proto and Peroxide equal to	100·	100.	100.	100·	100·07	100·06			
Metallic iron, .	28·84	33·46	29·10	27·45	33·46	34·75	28·88	26.29	28·65

	Phosphoric acid.	Silica.	Metallic iron.
Average, . . .	2·21	13·86	30·09
Maximum, . . .	50·5	20·90	34·75
Minimum, . . .	0·67	7·20	26·29

External characters of the stone:

A, B, E, F,	Colour gray; hard, compact, and high specific gravity, with very few oolitic grains—all alike.
C, D, G, H, I,	Softer stone; fracture uneven; many oolitic grains—all alike.

Analysis of Upleatham Ironstone.

	A.	B.	C.	D.	E.	F.
Silica, .	17·49	20·50	14·35	12·95	7·80	7·45
Protoxide of iron,	41·00	34·00	33·37	38·43	38·25	38·25
Peroxide of iron,	trace	7·00	3·50	2·10	6·50	5·80
Alumina, .	6·00	12·15	8·10	18·00	11·20	12·20
Lime, .	3·35	1·40	7·55	2·80	3 35	5 00
Magnesia, .	3·70	3·15	3·45	2·10	2·80	2·40
Sulphuric acid,	traces	traces	traces	traces	traces	traces
Sulphur, .	traces	0·06	traces	traces	traces	traces
Phosphoric acid,	0·45	2·55	1·50	trace	2·70	0·50
Carbonic acid,	25·70	15·50	25·38	19·18	24·20	25·40
Water, .	3·50	5·00	2·80	4·44	3·20	3·00
Protoxide and Peroxide equal to	101·19	101·31	100·	100·	100·	100·
Metallic iron, .	31·85	31·36	28·42	31·36	34·30	33·81

	Phosphoric Acid.	Silica.	Metallic Iron.
Average,	1·28	13·42	31·85
Maximum,	2·70	20·50	34·30
Minimum,	0·45	7·45	28·42

External characters of the stone,—

A,	The roof,	Cinnamon colour, friable, with white oolitic grains.
B,	The floor,	Dark green colour, compact, without oolitic grains.
C,	Intermediate stone,	Compact like B, without grains, faint blue green tinge.
D,	Do.	Light blue green, full of white oolitic grains, very soft stone.
E,	Do.	Composed almost entirely of white grains, held together by a green cement,—soft stone.
F,	Do,	The same as E, but intersected by the green stone, which is without white oolitic grains. Softish stone.

The specimens for the subjoined analyses were selected by taking a large number of stones from the mine, and crushing the whole, by which a very perfect average was obtained, but of course the fluctations in composition cannot be noted in the same way as in the preceding experiments. Mr John Pattinson, of the Clarence Iron-Works, has also analysed these stones, and our results are tabulated side by side.[*]

Average Analysis of the Normanby Ironstone.

	J. Pattinson.	Crowder.	J. Pattinson.	Crowder.
	Top, 3 feet.		Bottom, 8 feet.	
Silica,	15·24	23·50	10·36	11·95
Protoxide of iron,	33·86	35·08	38·06	39·05
Peroxide of iron,	0·47	1·43	2·60	3·69
Alumina,	6·92	3·90	5·92	6·41
Protoxide of Manganese,	0·96		0·74	
Lime,	5·82	4·56	7·77	6·35
Magnesia,	3·84	3·23	4·16	3·39
Carbonic acid,	25·00	22·38	22·00	22·29
Sulphuric acid,	trace.		trace.	
Sulphur,	0·40		0·14	
Phosphoric acid,	1·40	1· 4	1·07	1·66
Water,	3·69	4·52	4·45	4·37
	97·60	100·04	97·27	99·16
Protoxide and Peroxide equal to Metallic iron,	26·66	28·28	31·42	32·96

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[*] At the Normanby mines the band of stone is about 11 feet in thickness. The upper and lower portions are separated from each other by a thin band

External characters of the stone.

Top.—Dark sage green, compact, irregular fracture, containing a few shells but very few oolites.

Bottom.—Light bluish-green stone, filled with oolites. I have reason to believe, since making the above analysis, that the determination of the silica in the top seam by Mr Pattinson is more correct than my own, mine being simply the insoluble matter in hydrochloric acid, Mr Pattinson's being the same fused with carbonate of potass and soda, and the silica extracted therefrom. I have therefore adopted his average silica, not having time to repeat my own result.

In concluding the present communication it will perhaps facilitate the reference of such of my readers as are interested in the subject if I give a condensed view of the average value of the various stones examined.

The dark blue magnetic from the quarry.

Rosedale Stone.	Phosphoric acid.	Silica.	Metallic iron.
Average, . .		7·66	43·14
The drift 2 miles from quarry. Average, . .		11·84	36·86
Whitby Stone.			
Raithwaite mines, .		12 to 68	16·69 to 45·25
Sleightsbridge. Average, .		9·80	29·83
Tunnel stone. Average, . .		15·10	28·60
Cleveland Stone.			
Eston Nab. Average,	2·39	11·98	31·27
Hutton Low Cross. Average, .	2·21	13·86	30·09
Upleatham. Average, .	1·28	13·42	31·85
Normanby. Average, .	1·55	12·80	30·62

I have again to acknowledge the assistance I have had from my pupil, Mr E. C. Northcott, in the analyses of several Rosedale and other stones. My pupil, Mr G. Steward, has also, in several instances, rendered me valuable service.

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of pyrites. The upper portion is about 3 feet, the lower is about 8 feet in thickness.

Notes on the Basalts of the Giant's Causeway, County Antrim. By Edward Hull, A.B., F.G.S. (Plate I.)

The geological structure of the northern coast of County Antrim has already been so fully investigated by a goodly band of observers, amongst whom Dr Griffith and Colonel Portlock may be placed in the front rank, that I should no have presumed to tread upon their steps, did I hold to the principle that what has already been even *well* described should not again be attempted. Upon such a principle, what would become of our histories, books of travel, or treatises on moral or physical science? The indulgence, therefore, which is granted to writers of all classes can scarcely be denied to the geologist, when he endeavours to reproduce the works and investigations, accounts of which are buried amongst the archives of scientific institutions, or in works inaccessible to the general public.

It will scarcely be denied, that there are few districts—not excepting those which may be called the geological "lions" of our isles—which have been so thoroughly explored, that there is absolutely nothing left unnoticed. In general, each observer seizes upon one or more points which bear upon that branch of science to which he specially devotes his attention, and thus, by adding his quota to the general stock, he assists in perfecting the whole.

The feature in the geological structure of the Causeway district which I shall endeavour more particularly to dwell upon, is the stratigraphical position and relationship of the basalt, considered as a *bedded* rock, and therefore presenting many of the phenomena of *strata*, properly so called. But even this view of the subject is by no means new; the bedded structure of the Antrim basalts being admitted by nearly all the writers who have undertaken to treat of them, and who, sooth to say, have left little unobserved to their successors.

The physical features of the north-east coast of Ireland are of no ordinary kind. Whatever may have been the expectations formed, they will probably be found far to surpass them. The magnificent range of basaltic cliffs, extending for several miles in an unbroken coast-line, is almost unique amongst the British Isles, and perhaps is not much exceeded in boldness of aspect, or in variety and regularity in the columnar structure, by any coast-section in the world.

The range of coast-cliffs, stretching for nearly five miles from Ballintrae harbour to Bengore Head, has an average elevation of 500 feet, and in some places of fully 600 feet. The upper portions of these cliffs east of the Causeway Hotel are so precipitous, that they can only be scaled in two or three places; and for one of these, at least, the strong head and firm foot of the native kelp-burner are necessary. In general, the coast forms a succession of semicircular bays, bounded by vertical walls of prismatic basalt. The columns are arranged in tiers of superposition, each tier being distinguished by the size, form, or regularity of its columns; and the effect of these courses of majestic pillars sweeping horizontally round these natural amphitheatres, is indescribably beautiful. From Bengore Head, the coast bends to the south-east, and, in conjunction with the promontory of Fairhead, includes the Bay of Ballycastle. To the north-east, the island of Rathlin, which is composed entirely of basalt resting on chalk,* may be descried, and beyond this, in the distance, the Mull of Cantyre.

The surface of the table-land included by these coast-cliffs is very dreary, and is traversed by low ridges of basalt striking from west to east, the structure of which will presently be explained.

West of Bushmills the coast is less elevated, though often very rugged and bold. As far as the fine old baronial ruin of Dunluce Castle, it is composed of trap of various kinds, though the columnar structure is seldom exhibited; and at a short distance westward from the castle, white smooth cliffs of chalk rise from underneath the dark rugged masses of basalt. From this point to the Bay of Portrush, the superposition of these two diametrically opposite sorts of rock may be traced continuously for a distance of a mile, by the aid of both natural and artificial sections; and here they present many points of interest to which we shall presently revert.

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* For an account of the geology of this island, see paper by Professor Haughton. Jour. Geol. Soc. Dublin, 1851.

Perhaps the most prominent feature which at first strikes the eye of the geologist on viewing the basaltic cliffs of this district is their resemblance to stratified rocks. Indeed, of so uniform and regular a character is the bedded structure of these igneous rocks, that we are justified, when treating of them *en masse*, in applying to them the rules which belong to aqueous deposits. We may confidently speak of the "dip," "strike," and calculate the thickness of the Giant's Causeway, as we would do in the case of limestones, or as has been done when treating of the "bedded traps" of North Wales by the Government Geological Surveyors. It is remarkable how persistent are nature's operations, when we find the igneous rocks of ancient Silurian times presenting appearances identical with those of post-cretaceous age. I have seen on the northern flanks of Cader Idris greenstone dykes, bedded conformably with the slates by which they are inclosed, besides being perfectly columnar, with the axes of the columns perpendicular to the planes of bedding. And thus it is with the Causeway basalts. We find superimposed courses of columns, in each of which the columnar structure is developed in a manner and degree which seems to distinguish it from the other courses through horizontal distances of several hundred yards; and these courses, which doubtless represent distinct lava-flows, are amongst the principal causes producing the stratified aspect. Some of these tiers of columns are of remarkable regularity, and may be traced continuously for probably two or three miles along the highest portion of the cliffs. The section (Plate I. fig. 1) taken from the Horseshoe Bay, gives at least five such courses of columns.

		Ft. height.
e,	The highest, formed of imperfectly prismatic trap,	50
d,	Irregularly formed columns, 2 feet in diameter, .	35
c,	Irregular, massive, semiformed columns, . .	50
b,	Tier of small, bent columns, 6 inches in diameter, curved and radiating, and the line of junction with tier *a* well marked, ...	40
a,	The lowest tier, of perfectly straight, and nearly vertical columns, uniformly 18 inches in diameter,	40

At the base of the lowest tier the rock is covered up with shingle. The lines of separation between *a*, *b*, *c*, are well marked, the others less so; but between Horseshoe Bay and Bengore Head, from five to seven tiers of columnar trap will always be found forming the highest parts of the cliff.

The second cause of the bedded aspect of the trap of this coast is the frequent intercalation of beds of bright red ochre, and variously coloured trappean ashes, which Dr Griffith calls "the lithomarge beds." There are many of these seams through all parts of the series, but there is one bed which is very conspicuous, and extends uninterruptedly from the Causeway Hotel to Bengore Head, and beyond, till it dips into the sea, and is finally lost. Colonel Portlock appears to consider this bed as a volcanic mud, and in all probability it is a strictly stratified deposit. It is affirmed by Dr Griffith to contain pebbles of quartz, and to pass occasionally into sandstone.* Amongst the Causeway cliffs, however, the lithomarge bed occupies a *general* position of 200 feet above the sea; and by its bright red and purple colours contrasts finely with the dark masses of trap which enclose it. It may be observed in all states of decomposition, from that of globular trap to a kind of red and purple marl, speckled with white. A pathway about a foot in width winds along the upper part of this ochreous bed, which there could be little difficulty in following, were it not for the reflection that a false step would often be fatal. This path, however, affords the only entrance to some of the bays, and the native men and women traverse it without hesitation. It is really thrillingly interesting to watch for the first time a human being threading his or her way along the face of these precipitous cliffs.

The thickness of this lithomarge bed varies from 10 to 40 feet, and it divides the whole mass into two portions, which differ very considerably in their general structure. The trap underneath appears generally to be separated into thin regular beds, in which we can find but very rude approximations to the columnar structure; while, on the other hand, the mass above the marly zone exhibits those numerous successive tiers of columns, to which we have already alluded, and which,

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* Jour. Geol. Soc. Dub. Vol. I. Part iii. p. 158.

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PLATE I.

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Fig. 1.

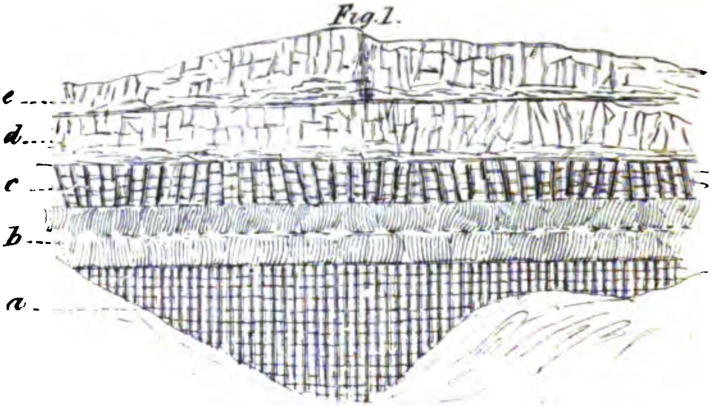


Fig 2.

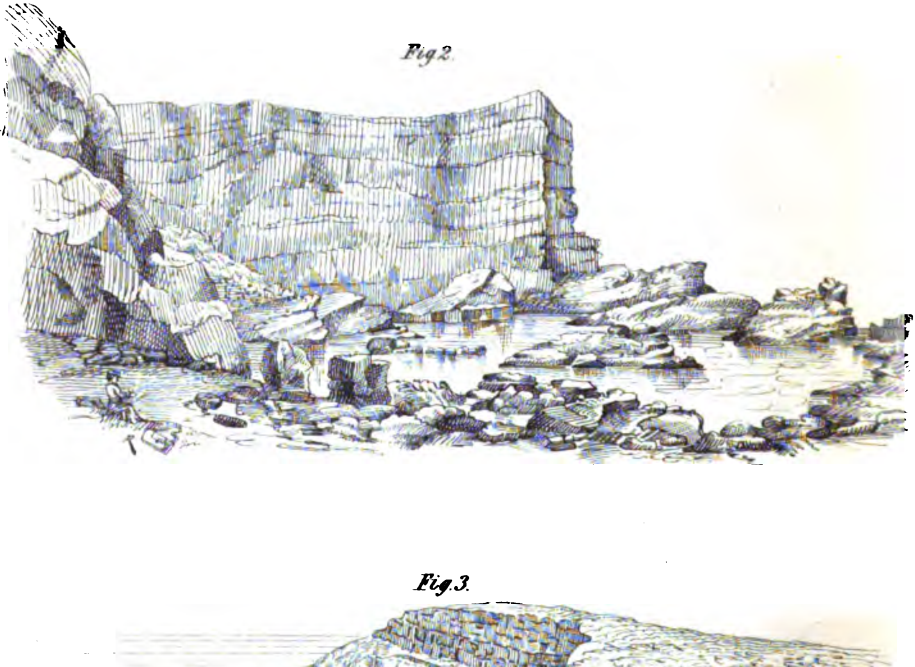
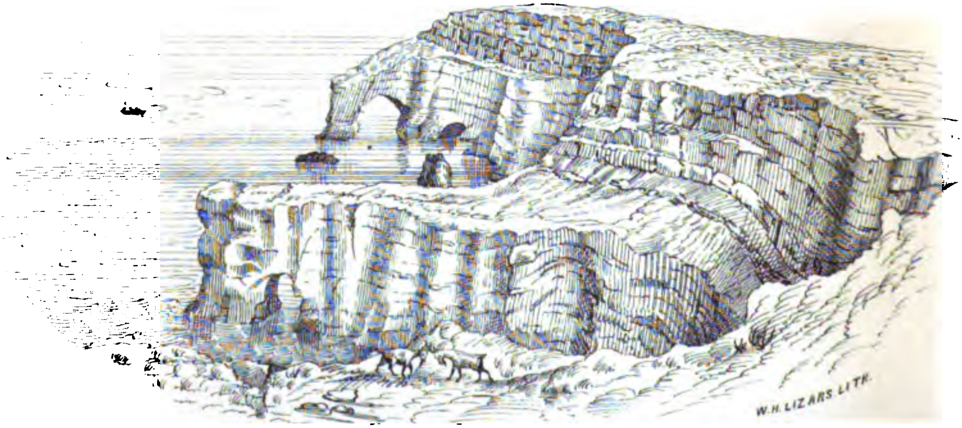


Fig. 3.



W. H. LIZARS LITH.

BASALTS OF THE GIANT'S CAUSEWAY, BY EDWARD HULL A.B., F.G.S.

when we regard the regularity of their arrangement and uniformity of size, cannot but fill us with surprise and admiration.

The progress of decomposition in the marly zone may frequently be examined in detail, especially near the Causeway Hotel, where it is most accessible. Where it has attained the bright hæmatitic colour, or where the iron has become entirely a peroxide, the decomposition is most complete; and from this point the various gradations may be traced to the opposite condition of the dark-greenish basalt. In the locality referred to, there are also some instances in which trap, which had assumed the *globular* structure, will be found in various states of decomposition. Each spherical mass, in this case, gives off successive concentric layers, which crumble away and change their colour; but while allowing that this and the other partings of marl and decomposed trap have assumed their present characters to a great extent under subaerial conditions, it appears probable, that this and the other decomposed beds of a similar nature represent periods of rest between succeeding volcanic eruptions, with their accompanying lava-flows. This supposition is borne out by the fact, that there are sometimes associated with them beds of lignite, which must certainly have required tranquil conditions for their deposition. When, therefore, we reflect that the thickness of the tabular trap series is, as I shall endeavour to show, at least 1300 feet, and is divided by from 30 to 40 beds of this decomposing volcanic sediment, we have another instance of the immense length of these geologic cycles which the mind assents to without being able to grasp.

The last cause of the bedded aspect of the Causeway basalt which I shall notice, is the alternation of bands of amygdaloid with others of an opposite character. The coast-cliffs between Bushmills and Dunluce Castle offer numerous examples, one of which is shown in Plate I. fig. 2. In these cases, the bands of amygdaloid, from their containing in their cells numerous crystals of zeolites, glassy felspar, and calcedony, are of a much lighter tint than the intervening spaces, while both follow the lines of bedding. It is difficult to account for this diversity of structure, for the alternate bands do not appear to partake of the nature of lava-flows, the lines of separation not being of that sharp and distinct kind which mark these phenomena amongst the Causeway Cliffs.

The basement beds of the Basalt. At the base of the partly inaccessible rock, crowned by the turrets and battlements of the old baronial ruin of Dunluce Castle, we find the white chalk exposed to view at ebb tide. The irregularity of the line of junction with the trap is here sufficiently apparent; for we may notice an arm of chalk stretched beside another of basalt,—the intervening bay decked with forests of marine vegetation, and bespangled with actiniæ, whose beautiful colours are finely set off by the pure white of the chalk. Upon scrambling over the rocks west of the castle for a few hundred yards, we at length come in sight of the smooth cliffs of chalk, worn into caverns, the roofs of which are supported in natural arches with their piers, while the upper part of the cliff is for the most part capped by dark masses of rudely-columnar basalt. (Fig. 3.) The dip of the chalk, as shown by lines of flint, is towards the south-east, at about 4°. That of the basalt is nearly parallel, but the line of junction is one produced partly by the juxtaposition of the rocks.

The basement beds of the basalt, as seen at Dunluce Castle, are of a very remarkable character. Upon first viewing them, I supposed that they were formed of globular basalt, partly decomposed; but upon hammering many of the blocks, and finding each differing in composition from its neighbour, I came to the conclusion that the mass was in fact a *conglomerate,* composed of waterworn blocks of trap, cemented by an ashy paste.

The blocks are of all sizes, from 5 feet in diameter, and may be advantageously viewed in the seaward cliff. They afford a great variety of trap, and are generally vesicular and amygdaloidal. There is no appearance of bedding, and the mass is at least 100 feet thick, resting immediately upon the chalk. In the court-yard of the Castle, one of these blocks, which is subangular, and composed of dark-blue, compact basalt, is fully 10 feet in diameter, and is imbedded in a trappean ash.

Of a similar character is the base of the trap, as far as it can be traced towards Portrush. It is often very admirably displayed in the picturesque cliffs which bound the coast. The lowest portion being formed of white chalk, worn into caverns, arches, and piers, while the dark basaltic rocks crown the summit. (Fig. 3.) Artificial sections are also opened by the cuttings for the government road; and within a mile of Portrush there is a section, for which we are indebted partly to art and partly to nature, which must not be passed over in silence. It exhibits a great pipe or channel excavated out of the chalk, in depth at least 150 feet, filled in with trappean conglomerate, identical with the rock of Dunluce Castle. This is a highly instructive section, as showing the nature of the floor over which the molten matter was poured. The phenomena presented in this section harmonize with those in the neighbourhood of Dunluce Castle. It is evident that the chalk had undergone considerable aqueous denudation, and that it was scooped into channels and hollows before the overflow of the lava. But the most remarkable fact, and one which, according to Dr Griffith, is universal, is this, that the chalk is no way *altered* at its contact with the igneous rock; on the contrary, it is as entirely granular within an inch of the basalt as at 50 feet further down. At the junction we frequently find nothing remaining but a mass of flint gravel, evincing the marine action just alluded to, and upon this the basaltic conglomerate. It is therefore evident that *in this locality* the first overflow of trap was not in the state of molten matter, but that it had become broken up, waterworn, and drifted, and had therefore assumed rather the nature of an aqueous than of an igneous rock. An example of a similar kind with the above is figured and described by Colonel Portlock,* and the denuded state of the former surface of the chalk appears to be coextensive with the rock itself. The most obvious explanation appears to be, that at the period of the first outburst of lava the depth of the sea was not great; at least the eroded surface of the chalk may be considered as evidence of this. Under this supposition, we may conceive that at some distance from the vent, the lava became

* Rep. Geol. Londonderry, p. 92.

broken up from the sudden generation of steam, and the escape of gases. If this hypothesis be correct, the bed of the sea must have continued sinking during the subsequent period of the eruptions.

The direction of the coast from Dunluce to Bengore Head is nearly parallel to the strike of the beds. At the latter point, however, it bends sharply round to the south-east, nearly at right-angles to its former direction. From Bengore Head to Ballycastle, the height of the cliff gradually diminishes, but it is still very bold and precipitous; and it is along this portion that the bedded structure of the basalt is more clearly illustrated.

This structure also exhibits itself in the configuration of the surface of the country. On crossing the strike from north to south, we meet with a succession of basaltic ridges, presenting their scarped flanks to the north-west, and dipping at small angles in an opposite direction. These are separated by wide valleys, generally of a swampy nature, being scooped out of soft beds of decomposing trap, similar to the lithomarge bed already described. On tracing these ridges to the coast we may see them descend in regular succession into the sea, at angles of from 3° to 5°, and then project out to sea, forming reefs, with intervening bays, representing the ridges and valleys of the table-land.

From this structure of the country, it is evident that the thickness of the basalt accumulates as we approach Ballycastle; when, therefore, we find in this locality coal-measures and chalk (rocks of much older date) arriving at the surface, it becomes evident that their presence must be connected with a fault, probably of very great vertical throw. I regret much that time did not permit of a full investigation of this point; but from what I was able to observe, it appears to me that this line of fault has marked the direction of the northern coast of Fairhead promontory; that it will cross the country a little to the north of Bushmills and Dunluce Castle, and will vanish in the synclinal of Portrush Bay, between the Skerries and the main-land, it being by no means an uncommon occurrence for faults to pass into rolls of the strata.

That there are faults in this district later than the basalt, may be inferred from the fact of their occurrence in the island of Rathlin, as described by Professor Haughton,* and it is not improbable that some of the dislocations which, according to him, range north-west, may be offshoots from the main line which I have here indicated.

The *throw* of this fault will probably be found equal to the whole thickness of the basalt, measured from below the sea-bed at the Causeway coast to near Ballycastle, and this cannot be under 1300 feet, and is probably more. I am aware, however, that Colonel Portlock does not consider the tabular basalts to attain a greater thickness than 700 feet.† This, however, is a question which will depend for its solution on accurate measurements in the Causeway district.

Notice of the Copper Turf of Merioneth. By WILLIAM JORY HENWOOD, F.R.S., F.G.S., &c.‡

The copper ores which have been found in some abundance amongst the mountains of Merionethshire have not occurred in such long and regular lodes as characterize many other metalliferous deposits; but are for the most part, obtained from the net-work of irregular strings, which,—chiefly composed of quartz and carbonate of lime in ever-varying proportions, and frequently mixed with *epidote* and other minerals—conform more or less to the natural joints of the hornblende-slate or greenstone.

The district to which my labours were directed a few years ago, is the wild and romantic one, well known to tourists, about three or four miles north-west of Dôlgelly, on the way to Trawsfynnydd; and occupies the irregular triangle included between the rivers Mawddach and Babi. Although the surface is generally steep and rough, there are some gentle declivities, and small vales so slightly inclined as to have permitted the formation of peat, and it is in these that the copper-turf has been wrought.

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* Journ. Geol. Soc. Dub.

† Report, &c., p. 156.

‡ Read before the Royal Institution of Cornwall, October 31, 1856.

At Bryn-Coch numerous short, thin veins, and isolated spots of copper-pyrites occur in a small rocky eminence; and the water oozing and trickling from it enters a field, long cultivated, but from its infertility called Cae Drwg (the bad field). The soil was examined in my presence, and gave traces of copper.

At Benrhos there are small quantities of antimonial grey-copper ore, of copper pyrites, and of the blue and green carbonates of copper. The earth which receives the drainage of pits sunk in pursuit of these ores, gave slight but unequivocal indications of copper.

Copper-pyrites occur at Tyn-y-myndd, but not abundantly. Immediately below, at Maes-y-Glwysan, the vegetable mould is about three feet in thickness, and reposes on a bed of rotten wood (? hazel) and decayed roots of grass of six inches deep; no sign of copper was detected in either of them; but a bed of peat beneath afforded a moderate produce of copper, and has been occasionally wrought.

By far the best known and most extensive deposit of copper-turf, however is at Dolfrwynog, where some 70 acres of it were worked about 40 years ago; at the base of a hill which forms the southern bank of the Mawddwch and receives the drainage as well of an extensive common, as of a long level driven on a vein of quartz, in which were found several irregular masses of copper-pyrites weighing some tons each. The chief repository of the copper is a bed of peat of about 18 inches or two feet in thickness, which consists for the most part of dead grass mixed with great quantities of rotten wood (oak and hazel). Beneath the peat there is a bed of stones a few inches in thickness, evidently the *débris* of the neighbouring rocks. Many of the stones contain iron-pyrites in abundance, and some of them are thinly encrusted with the green carbonate of copper. A second bed of peat underlies the fragmentary deposit, and also affords copper; but so scantily that it has not been wrought, and its thickness has not been ascertained. Some of the lowest portions of the upper peat-bed were so rich in copper, that they were carried to the Swansea smelting works in the condition in which they were extracted; some of the leaves are said to have been covered with a thin pellicle of bright metallic copper; nuts were coated in like manner, and on being broken afforded also a kernel of the same; and I was informed that the copper was in some cases deposited between the fibres of the wood; so that on being cut it exhibited alternate layers of vegetable matter and of metal.

These were, however, exceptional cases. Ordinarily the turf was cut and dried by exposure to the air, and when sufficiently dry it was set in heaps and burnt. As the mass ignited, recently cut turf was added, which was soon dried by the heat; but especial care was taken that the burning heap should not burst into flame, for it then fuzed into a slag, which would not suit the purposes of the smelter. All the utensils employed, excepting only those for cutting the turf, were of copper, as it was found that iron ones were rapidly destroyed. After the fire had been continued for 8 or 10 days without intermission, the ashes were fit for the furnace; and they were then sold to the Swansea manufacturers.

I was informed that in one year 2000 tons of ashes had been sold, and had realized a profit of about £20,000. At the time of my visit, there still remained an enormous quantity of copper turf, but as its ashes would not yield more than about 2½ per cent. of copper, it was thought too poor to be wrought to advantage.

It is said that a similar formation occurred near the Parys and the Mona copper mines in Anglesea; but it was not wrought when I visited them.

Persons conversant with the copper-turbaries, consider the presence of metal in the soil indicated by the growth of the *Sea Pink* or *Thrift* (*Armeria maritima*), which appears to flourish there with remarkable luxuriance.

3 Clarence Place, Penzance, October 29, 1856.

On the Physical Sciences which form the Basis of Technology; being the introductory prelection for 1856. By GEORGE WILSON, M.D., F.R.S.E., Regius Professor of Technology, University of Edinburgh.

In my inaugural lecture of last year I endeavoured to define the objects of Technology. I propose, on this occasion, to consider the physical sciences on which it is based. Yet at the outset, I cannot but ask myself, which of these sciences does not lend support to Technology, and on what plea shall any be omitted from the list of its ministers? In reality none can be. Technology is the sum or complement of all the sciences, which either are, or may be made, applicable to the industrial labours or utilitarian necessities of man. But though this be the case, certain departments of knowledge stand so much more closely related than others to the recurring urgencies of daily labour, that to them a pre-eminent importance must be assigned, in any endeavour to number the scientific pillars on which Technology rests. And, in the first place, to narrow our horizon within limits that can be compassed, let me remind you that our science ministers only to the physical necessities of man. It does not acknowledge his imagination, or directly concern itself with his ascription of beauty to some things, and of ugliness to others. It does not acknowledge his heart, or take heed of his loves and his hates, his exultations and despairs. It does not acknowledge his conscience, or care about right or wrong, or affect any interest in his moral welfare. It does not even pay court to his intellect, or profess sympathy with his cravings after knowledge for its own sake, his impatience of ignorance, and longings for perfection. It knows him only as the paragon of animals, the most helpless, though most gifted of them all; and seeks only to meet his fleshly wants; to enlarge the practical empire of his senses; to make his arms stronger, his fingers nimbler, his feet swifter, and with help from Hygienics, his frame more stalwart, himself a more smoothly moving, well-ordered, living machine.

Putting aside, then, all questions of Beauty, Morality, or

Philosophy, we are to consider where man can acquire the knowledge which will give his body the victory in the daily battle of life. The problem which he has to solve is a vast one; so vast, indeed, that instead of attempting to enumerate the items which make it up, I will say, in one word, that his capital to begin with is one wise head and ten skilful fingers, and that with these he must build such a Crystal Palace as the world saw in 1851, and stock it with all its wondrous contents. To solve this problem, he must fall back upon the sciences which reveal the properties of matter, and the modes of altering it.

The sciences in question are familiarly divided into Natural History, on the one hand, and Experimental Physics, including Chemistry, on the other. Natural History, on this view, is the science of all those objects, phenomena, and laws, which physical nature *spontaneously* presents to our view; whilst Experimental Physics is the science of all the *additional* objects, phenomena, and laws, which our interference with nature enables us to bring under our scrutiny.

Such a twofold division, however, is not sufficient for us. All the sciences observe and register the phenomena and laws which nature presents within the circle allotted to each; and are therefore portions of Natural History, or *Naturalistic.* All the sciences, also, but Astronomy, experiment upon, or subject to trial, the objects presented by nature to each; and are therefore *Experimental.* The difference, accordingly, between the majority of the sciences which are observational, and those which are experimental, is one only of degree. A distinction of a much deeper kind lies in the fact, that the experiments which the one characteristically makes are simply more precise observations of what nature presents; whilst those which the other characteristically makes, imply the transformation or transmutation of natural objects, and the study thereafter of the results of such transformations.

In addition, however, there is a third class of experiments, neither simply observational nor transformational, but *registrative* and *directive,* in modes which I shall presently consider. And, further, Biology, the science of Plant-Life and

Animal-Life, must have a place to itself, from the peculiarity of the subject-matter with which it deals.

I would arrange the physical sciences, accordingly, as related to Technology, in three groups.

I. Naturalistic, Observational, and Registrative sciences, of which the chief are Astronomy and Geology, including Meteorology, Hydrology, Physical Geography, and Mineralogy, as well as descriptive Botany and Zoology.

II. Experimental, Transformational, and Directive sciences, of which the chief are Chemistry and Mechanics, as well as Heat, Optics, Electricity, and Magnetism.

III. Organic sciences: namely, Functional or Physiological Botany, which treats of the plant-life of non-sentient organisms; and Functional or Physiological Zoology, which treats of the animal-life of sentient organisms.

This complex, nominally triple arrangement, is essentially twofold, in its relation to Technology. The industrialist must study one class of the physical sciences, or rather one side of all physical science, to consider what gifts nature offers him with her liberal hand. He must study another class of these sciences, or rather another side of all physical science, to discover how to turn those gifts to account. There is always, on the one hand, something to be had for the taking, a raw material, a physical phenomenon, a physical force. There is always a necessity, on the other hand, for expenditure of skill to effect the *transformation* of the raw material, the *registration* of the phenomenon, the *direction* of the force. To render this clear, I must enter a little more fully into details; and these may be discussed under three heads.

One of the greatest services which observational science is continually rendering to Industrialism, is the discovery of natural substances, mineral, vegetable, and animal, possessed of useful but latent properties. A service not less great, is then rendered by transformational science pointing out how to modify this gift of nature, so as to call into active existence its hidden, precious qualities. Thus, to take a complex but striking example. Through observational science we may discover a soil more or less fertile, all the world over; but transformational science must show us how to fence and till it, how to drain or irrigate, and manure it, before it can be made a fruitful field. Geology, striving ever to reach nearer to the centre of the earth, finds coal for us. Chemistry teaches us how to coke, *i. e.*, literally to cook, this raw material, and how to distil it into naphtha and gas. Mineralogy selects iron-ores for us; Chemistry converts them into steel; and Mechanics forges that into bars. Descriptive Botany plucks a wild currant; Physiological Botany changes it into a sweet grape; Chemistry ferments it into wine, and transforms that into ether. Descriptive Zoology lays its hands on a caterpillar; Physiological Zoology nurses it into a strong silkworm; Chemistry bleaches and dyes the silk which it spins; and Mechanics weaves it into velvet.

A second most important service which observational science renders to Industrialism, is by discovering striking natural phenomena, such, for example, as the eclipses of the heavenly bodies, the alterations in the pressure and temperature of the atmosphere, the motions of a loadstone suspended freely, and the like; which experimental science can so *register* as to make them guides of the greatest value in a multitude of practical labours.

Thus, there is perhaps no more familiar natural phenomenon than that the sun leaves in shadow that side of a body which is turned from him, and that this shadow changes its place in obedience to the apparent motion of the sun. And with no more than this fact of nature made over to him, even the barbaric mechanician constructs his useful sun-dial, and the day measures itself into hours. So also the bar of steel, which the experimenter has rubbed with a natural loadstone, becomes a compass-needle, and deserves its name, by threading the mariner's way through all the labyrinths of the sea. "The wind," said King Solomon, the greatest naturalist of his time, "goeth toward the south, and turneth about unto the north: it whirleth about continually: and the wind returneth according to his circuits." And the sailors of the ships of Tarshish had, like our sailors, their wind-vane and streamers, their anemoscopes and anemometers, though they did not so name them, to tell from what quarter, and with what force the wind blew. The complex and beautiful art of navigation abounds in examples of what I have called Registrative Science. The night-glass, the sextant, the thermometer, the barometer, the sympiesometer, as well as the compass-needle and the simple wind-vane, by the indications of which the sailor makes his ship go straight, as if on a railway, to the desired haven, are industrial instruments of the highest value. No one will doubt this who visits any of our fishing towns during the herring season, when the boats are at sea, and observes how the straining eyes of loving mothers and wives are fixed on the weathercock, and those of faithful fathers and brothers on the doubtful barometer. Here natural phenomena are not merely analysed into greater simplicity, which is the function of observational science; neither are they interfered with, which is the function of tranformational science; but they are made, as it were, to prolong their existence till not merely the speculative philosopher, but also the busy workman, has been roused to their presence, and has had opportunity to profit by their warning. We hold, as we may say, the key down, and let the steam-whistle scream till all have heard the ominous note; we keep the signal flying that all may see that the wind has changed, and the fleet is weighing anchor. This cannot be done without instruments, which, if possible, should be automatic or self-acting; and such instruments are the fruit only of much and varied experimental trial; yet the experiments, as something more than observational, and as in no respect transformational, stand apart, and may, till a more distinctive place is found for them, be ranged under Registrative Science.

A third most important service which observational science renders Industrialism, is by discovering natural powers, forces, or energies, which in their spontaneous action work both good and ill to man; but when disciplined and controlled by what I have proposed to call directive science, become his unreluctant slaves and willing workmen.

Thus, meteorology reveals to us the laws according to which great currents are occasioned in the atmosphere; and then mechanics builds its windmill, and the most impatient breeze that tries to hurry past must stop, and, like a chained slave, take its turn at grinding corn or drawing water. "The wind," said He who spake as never man spake, "bloweth where it listeth, and thou hearest the sound thereof, but canst not tell whence it cometh, and whither it goeth;" but provided only it do not cease to blow, the mariner can turn his sail one way, and set his rudder the other, and make the wind carry him round and round the globe, whithersoever he will. These are achievements of Directive Science, and multitudes more might be named. The clock, for example, moved by the falling weight, the hour-glass, with its noiseless shower of sand, the wheel turned by the stream of water, the mill wrought by the ebb and flow of the tide, the sea salt crystallized by the heat of the sun, the boracic acid of the volcanic lagoon evaporated by the heat of the volcano, the direction and force of the wind noted down on paper by the anemometer, *i.e.*, by a pen put between the fingers of the wind itself, the photographic pictures which we compel the sun to draw with a chemical pencil of his own providing, as often as we choose to spread a tablet before him: those are but a few familiar examples of the office of Directive Science. Between it and Registrative Science it is impossible to draw a sharp line of demarcation. A balance or steel yard, for example, falls as much within the one category as the other; so do all kinds of chronometers. But where we avail ourselves of a Natural agency, like the winds, as a mechanical motive power; or like solar heat, to induce chemical change, we may conveniently refer it to Directive Science; whilst where we employ such agency simply to signal to us a change in events, as when the sun-dial marks the passage of time, the compass-needle altered direction in space, or the thermometer altered temperature of the atmosphere, we may with equal propriety refer it to Registrative Science.

Again, as Registration is but carefully made, fully registered, or prolonged Observation, they must shade into each other. It is important, however, to keep them as distinct as we can in reference to Technology; and the essence of this distinction lies mainly in the different nature of the instruments which they severally employ. The object of the naturalist, using that term in its widest sense, is to separate the complex wholes which on every side nature presents, into their simplest components. His chief implements, accordingly, are analytical, and are represented by such instruments as the telescope of the astronomer, the microscope of the botanist, the mining axe of the geologist, the hammer of the mineralogist, the scalpel of the anatomist, and the voltaic battery of the chemist.

The instruments of Registrative Science, on the other hand are, in the simplest sense of the words, *significant* and *metrical*. They signal the occurrence of a phenomenon; they note the presence of a force, indicate the line of its action, and often also measure its intensity and quantity. Such instruments are the wind-vane, compass-needle, thermometer, barometer, chronometer, voltameter, and many more. These instruments are part of the armament of the Naturalist, who is free to use them all; but the disciple of Registrative Science is not equally free to use the analytical implements of the observer. I may compare the difference between the function of the registrars and the observers in science, to that which subsists between the musicians of an army and its fighting men. The drums and trumpets of the band are at the disposal of any combatant officer who has lawful occasion to give a signal to the troops; but the band-master himself never meddles with those exceedingly analytical instruments, the guns and swords of the active combatants.

Thus, then, in all its departments, and at all times, Technology stretches forth both hands: with the one, receiving from the Observational Registrative Naturalist, an organic or inorganic substance, a physical phenomenon, or a physical force; and with the other, receiving from the Directive, Transforming Experimentalist, the means of changing that rude material into many a precious product; that terrestrial or sidereal, or cosmical phenomenon, into a faithful watcher and measurer, that wild force into a patient, docile servant.

After this explanation, I shall fall back upon the familiar division of all the physical sciences, whether dealing with dead or living matter, into two groups, viz.:—

I. The Observational and Registrative, Natural History Sciences.

II. The Directive and Transformational, Experimental Sciences.

Let us look more particularly at these contrasted groups. The sciences which illustrate the contrast best are astronomy on the one hand and chemistry on the other. I shall commence with them.

Astronomy, the oldest, the grandest, and the ripest of the sciences, is, in relation to the physical objects which it considers, almost purely observational. When we study it, we are like men reading a book under a glass case, the leaves of which are slowly turned over by a self-acting mechanism, so that two pages only can be studied at a time. If we quickly exhaust the meaning of these pages, or tire of their perusal, we cannot hasten the period when the leaf will turn over; and if we miss their meaning, or wish to dwell upon it, we cannot arrest or delay the turning of the leaf, but must wait, it may be for a lifetime, till the cycle is complete, and these pages are opened again.

The magnificent clockwork of the heavens, with all its fiery glories, its stately movements, and faultless machinery, is far beyond and above our slightest interference. We cannot reach it, nor, if we could, dare we approach to touch it. The humiliating contrast which any comparison of the two brings to light, between the immensity and majesty of the heavens and the littleness and impotence of man, presses too heavily on the heart to allow us easily to contemplate with merely intellectual eyes the unapproachableness of the objects of astronomy. The greatest of modern astronomers have often with their lips, and always, I believe, with, their hearts, uttered their amen to the star-loving king of Israel's confession, "when I consider thy heavens, the work of thy fingers, the moon and the stars which thou hast ordained; what is man, that thou art mindful of him? and the son of man, that thou visitest him?"

But upon this moral aspect of the peculiarity of astronomy under consideration I have no desire at present to dwell. I would rather on this occasion forget it; for, in truth, if man has reason to feel proud of any one of his achievements it is of his science of astronomy; and the limitations which restrict its study justify his pride the more.

Those limitations are great. Ages before the existence of scientific astronomy the question was put to the patriarch Job, "Canst thou bind the sweet influences of Pleiades, or loose the bands of Orion; canst thou bring forth Mazzaroth in his season? or canst thou guide Arcturus with his sons?" And when Job in his heart, if not with his lips, answered the Almighty, No, he answered for all his successors as well as for himself. Astronomical problems accumulate unsolved on our hands, because we cannot as mechanicians, chemists, or physiologists, experiment upon the stars. Are they built of the same materials as our planet? Are they inhabited? Are Saturn's rings solid or liquid? Has the moon an atmosphere? Are the atmospheres of the planets like ours? Are the light and heat of the sun begotten of combustion? and what is the fuel which feeds his unquenchable fires? These are but a few of the questions which we ask, and variously answer, but leave in reality unanswered, after all. A war of words regarding the revolution of the moon round her axis may go on to the end of time, because we cannot throw our satellite out of gearing, or bring her to a momentary stand-still; and the problem of the habitability of the stars awaits in vain an *experimentum crucis*. The only exceptions which may be made to the essentially non-experimental character of astronomy are furnished by the opportunity granted us to modify to the extent of our power the sidereal influences, such as heat, light, and actinism, and the sidereal bodies, such as the meteoric stones which reach our globe. The sidereal influences, however, have passed from the domain of Astronomy into that of Physics, before they come under our examination; and the meteoric stones are terrestrial minerals before we can analyse them. Optics and Chemistry claim them from Astronomy.

The astronomer, accordingly, must be content to be the chronicler of a spectacle, in which, except as an onlooker, he takes no part. Like the sailor at the mast-head in his solitary night-watch, he must see, as he sails through space in his small earthly bark, that nothing escapes his view within the vast, visible firmament. But he stands, as it were, with folded arms, occupied solely in wistfully gazing over the illimitable ocean, where the nearest vessel, like his own, is far beyond summons or signal, and the greatest appears but as a speck on the distant horizon. His course lies out of the track of every other vessel; and year after year he repeats the same voyage, without ever practically altering his relation to the innumerable fleets which navigate those seas.

Astronomy is thus pre-eminently the Observational Science; and represents in its greatest purity that function of the physical sciences which consists in the investigation of the works of God, as untouched by man. Such investigation is the basis of all our knowledge and all our industry. And if our human pride ever tempts us to undervalue the astronomer as compared with his brother philosophers, because he is only a spectator, and not an actor, on the field which he cultivates, let us remember that the ever-changing spectacle which he witnesses is one which not only demands for its full appreciation the whole intellect of man, but far surpasses in grandeur the sights which open to the eyes of other students, even though they are free to add to the glories which God has made to shine forth from all his works, every hidden grace which human can bring to view.

This superhuman character of astronomy was recognized from the first. As a bare scientific truth, it was implied in the declaration of the great Greek mechanician Archimedes, that *if* he had a place whereon to stand he could move the world. The *ποῦ στῶ*, the whereon to stand has not been found. The greatest practical mathematician of antiquity incidentally proclaimed that, though man is free elsewhere to compel nature to teach him the mysteries she seeks to conceal, and to submit to his interference with her, there is one territory of hers, and that her vastest, where she brooks no interference, and he cannot stretch her on the rack, or torture her secrets from her. We have no standing place among the stars, no liberty to lay finger upon them. What we know of them they have told us, spontaneously revealing at all epochs more than we are able or willing to receive. This thought, which was latent in the Greek philosopher's utterance, and in part proclaimed in the question already quoted as addressed to Job, was announced in all its fulness by the inspired Hebrew king—"The heavens *declare* the glory of God: and the firmament *sheweth* his handiwork. Day unto day uttereth speech, and night unto night sheweth knowledge."

Unconstrained and spontaneous though the revelations of astronomy thus are, their value to industrial science cannot easily be overrated. Our modes of measuring space and time, and in connection with both the art of navigation, are applications to the most useful purposes, of truths which astronomy offers freely to all who have capacity enough to receive them. The phenomena, in truth, of which Registrative Science takes cognizance, are in great part furnished by this liberal giver; who has also taught us laws regulating many of the forces with which Directive Science deals. It is sufficient on this head to refer to the laws of gravitation.

Astronomy, further, is related to the Experimental Transformational Sciences in a very curious way. If imaginative men, needlessly fearing that the progress of physical science will prove fatal to poetry, rejoice that the sun is as dazzling to us as to our forefathers, and that we no more than they can wreathe our hands in the golden manes of his fiery coursers; at least we can watch with more exulting delight the sparks which their pawing feet strike out of the starry pavement, and can see other than romantic reasons why they rejoice to run their race.

Daily the conviction deepens among those who have studied the matter, that with a few exceptions all the physical powers which man wields as movers or transformers of matter are modifications of sun-force. It was bestowed upon antediluvian plants, and they locked it up for a season in the woody tissue which it enabled them to weave, and afterwards time changed that into coal; and the steam-engine, which we complacently call ours, and claim patents for, burns that coal into lever-force and steam hammer power, and is in truth a sun-engine. And the plants of our own day receive as liberally from the sun, and condense his force into the charcoal which we extract from them, and expend in smelting metallic ores. With the smelted metals we make voltaic batteries, and magnets, and telegraph wires; and call the modified sun-force electricity and magnetism, and say it is ours, and ask if we may not do what we like with our own.

And again, the plants we cultivate concentrate sun-force in grass, hay, oats, wheat, and other fibres and grains, which seem only suitable to feed cattle and beasts of burden with. But by and by a Spanish bull-fighter is transfixed by this force, through the horns of a bull, and dies unaware of his classical fate, pierced to the heart by an arrow from Apollo the Sun-God's bow. On English commons prizes are run for, by steeds which are truly coursers of the sun, for his force is swelling in their muscles and throbbing in their veins, and horse-power is but another name for sun-power. Nor is it otherwise with their riders; for they, too, have been fed upon light, and made strong with fruits and flesh which have been nourished by the sun. His heat warms their blood, his light shines in their eyes; they cannot deal a blow which is not a *coup de soleil*, a veritable sun-stroke; nor express a thought without help from him.

In grave earnestness, let me remind you, that as force cannot be annihilated any more than matter, but can only be changed in its mode of manifestation, so it appears beyond doubt that the force generated by the sun, and conveyed by his rays in the guise of heat, light, and chemical power, to the earth, is not extinguished there, but only changes its form. It apparently disappears when it falls upon plants, which never grow without it; but we cannot doubt that it is working in a new shape in their organs and tissues, and reappears in the heat and light which they give out when they are burned. This heat, which is sun-heat *at second hand*, we again seem to lose when we use plants as fuel in our boiler-furnaces; but it has only disguised itself, without loss of power, in the elasticity of the steam, and will again seem lost, when it is translated into the momentum of the heavy piston, and the whirling power of a million of wheels.

The second-hand heat of the sun appears equally lost when vegetable fuel is expended in reducing metals; but oxidize these metals in a galvanic battery, and it will reappear as chemical force, as electricity, as magnetism, as heat the most intense;

and, in the electro-carbon light, will return almost to the condition of sunshine again.

This second-hand plant-heat appears equally lost when vegetables are eaten by animals, but in reality reappears in their so-called animal heat, and in the chemical, electrical, and other forces which act upon and within them. It reappears, also, I do not doubt, in their vegetative life, and changes into what we call vital force. Do not, however, misunderstand me, as going beyond physical force. Life, remember, is not mind. The immaterial spirit, the immortal soul, is far above the Sun. We know him, and we know ourselves, but he knows neither himself nor us.

Astronomy thus stands much nearer industrialism, in all its departments, than perhaps any of us fully realize. I cannot wonder that men, even practical men, were once astrologers. A dim sense of obligation to the heavenly bodies for something more than starlight was obscurely felt perhaps by all, and rested, as the stable foundation-stone of a worthless building, at the bottom of the fantastic erection which formed the astrology of the middle ages. And still more intelligible is sun-worship. Only by a fallen and a rebel angel could such words be uttered as "I add thy name, O! sun, to tell thee how I hate thy beams." The worst of men would recall that God "maketh his sun to rise on the evil and on the good;" and across the chasm of centuries I own to a sympathy with the pagan who worshipped as a god the bountiful Sun.

If now we turn to Chemistry, as pre-eminently the Experimental Science, we shall find everything reversed. Were we to personify ancient chemistry, we should represent her as a speechless priestess of nature, sworn to silence, loving concealment, and the most grudging of givers. She persuaded mankind for centuries that there were but four elements, Air, Earth, Fire, and Water; and so cunning a conjuror was she, that though in open day she was continually taking them to pieces before the eyes of all, they did not detect the trick, but pronounced each fancied element one and indivisible. She still stretches forth her hands, filled with truths the most wonderful; but those hands are clenched, and you must borrow her strength before you can open them. Every substance under her control is a locked casket, with a concealed key-hole, and no key. You must first, if you can, find the key-hole, which a search for ages has often failed to find; and then study as best you may the hidden wards of the lock; and thereafter forge not a pick-lock, but a perfect key, which in a multitude of cases will open only the lock for which it was made.

The characteristic attitude, accordingly, of the chemist, is very different from that of the astronomer. It is true that the former, like the latter, and like all the students of nature, must deal much in simple observation. The colours, the odours, the tastes, the crystalline shapes, the densities, the melting and boiling points, and many analogous properties or phenomena presented by bodies, are carefully noticed and registered by him. In observing these, however, he is not doing his own work, but that of the physicist: his proper work begins where that of the latter ends. Whatever is brought him, whether meteoric stone from the realms of space, or mineral from the bowels of the earth, or essence of plant, or secretion of animal, crystal or liquid, or vapour or gas, he regards as coming in "a *questionable* shape." Is it a compound; and if so, what are its ingredients? Are they compound in a less degree, or in essence simple? Are there any bodies truly simple; and if so, how many? What new compounds is it possible to produce by uniting in ways which nature has not followed the simple and complex substances which she supplies?

To act out in practice those queries and others, the chemist at all times must keep both hands busy. His arms may never be folded. No mighty panorama unrolls itself before his eyes, requiring only that he fix upon it an unwavering gaze. No mysterious strangers longing to unburden their bosoms of truths known only to themselves, seek his cell as a confessional, and whisper revelations into his ear. He must be likened to one of those grim inquisitors of the middle ages, whom no man willingly answered, and who believed in no man's answer unless he wrung it from him by torture. In truth, there is a wonderful similarity between the old drawings of the inquisitors putting their victims to the question, and the old drawings of the

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alchemists testing the objects of their suspicions. In both cases there is a dark subterranean chamber, with ominous fires lighting up the gloom. In both the presiding genius is a wasted old man, with a haggard look, and the pitiless, unsatisfied eye of a bird of prey which has often missed its quarry. In both, obsequious familiars stand ready to do the bidding of the senior, and strange machines and implements hang upon the walls and burden the floor. In both, to complete the picture, all eyes are fixed upon the doomed object of suspicion in the centre, from which, whatever truths mechanical pressure can crush, or fire and water melt or dissolve, will presently be gathered. The analogy is not a fanciful one, for unless history has wronged the mediæval Inquisition, it reversed the rule of English jurisprudence, and counted every object of its notice guilty, till he proved himself innocent: and such is certainly the law of the chemist, who, like the French terrorist, regards every substance as "suspect" of being something else than it seems, and puts a mark even upon those against whom nothing has been proved before his searching tribunal.

But this comparison illustrates only one-half, and that the less important half, of what distinguishes chemistry from the other sciences. It is not that it experiments, for all the sciences, excepting astronomy, experiment. Nor that it tries to analyze everything, for every science is analytical, none more than astronomy; and all to the extent of their power treat nature inquisitorially. Chemistry differs only in degree from the other sciences in this respect, although the degree of that difference is immense. But it may be said to differ in kind from the other sciences, in its power to modify or transform matter, and to effect the creation of new bodies. That it can separate substances into their simpler ingredients, perhaps into their veritable elements, is a legitimate source of pride; but, in relation, at least, to the arts of life, a greater ground of exultation is, that it can unite those elements or ingredients so as not only to reproduce the compound from which they were taken, but to bring into being, for the first time, compounds new to man. No wonder, then, that Nature is jealous of her chemical secrets. She knows that we shall never try to rival her in lighting up suns and stars, in building granite mountains and digging volcanic craters, or in shaping blades of grass, and manufacturing from it fleeces of wool. For the making of these she has the patent which we cannot infringe. But from the moment that chalk was proved to consist of carbonic acid and lime, the patent for making it expired; and we can not only produce chalk at will, out of its components, carbonic acid and lime, but out of their elements, carbon, oxygen, and calcium, we can make novel compounds, and forestal nature in her own market.

The chemist is thus pre-eminently a transformer, a transmuter, a maker; in one word, a creator, to the full extent a mortal can be. God has given him one world; and, in addition, has permitted him to make as many worlds from it as he can. And every day he is making a new, and still a newer globe, new metals, new earths, new alkalies, new acids, new foods, new drinks, new airs to breathe. Alexander the Great wept because he had not another world to conquer; but no chemist needs weep on that account, for he may be first creator, and then conqueror of world upon world. Since the century began, Davy gave us one new world; Berzelius gave us another; Liebig a third: many more are in store for us.

The ancient chemistry, a mute priestess, has long confessed that her oracles are dumb, and herself listens to the revelations of her unresembling successor. Modern chemistry is an active, full-voiced workman, a daimonic blacksmith, like the Scandinavian Thor or the classical Vulcan; only I do not know that it is essential to our conception of personified chemistry that he should be represented lame. This blacksmith's chief tools are two hammers. The one of them he calls *analysis*; it is a *crushing* hammer. If you bring him anything, no matter how rare and costly, he begs you to lay it on his anvil and let him try it with his tool. There are not many things in the world that can bear uninjured its stroke. The few that can, he sets great store upon, puts aside with a certain reverence, calls elements, and distinguishes by names. Some sixty such elements are all that he has yet encountered; and, with an improved hammer, he hopes to break down many of these. The multitude of bodies that give way before his blows he continues to smite till they will break no smaller, and the grains that remain he separates according to their kinds, and puts into that parcel of the sixty invincibles to which each belongs.

His other hammer he calls *synthesis;* it is a *forging* hammer. Beneath its strokes any two or more of the sixty unbroken residues of his crushing work can be welded together, made to incorporate into new substances, and assume new forms. Two, ten, twenty, the whole sixty simplest bodies may be taken, in equal or unequal quantities, and from each of the endless mixtures a new wonder will take shape under the hammer.

So he stands with a weapon in each hand, for he is ambidextrous; and moreover, he can wield both weapons at once. Neither are these his only tools. Equipped with them and with others, the chemist is pre-eminently a transformer, from the four-fold force which he can bring to bear upon material things.

First; He can analyse or decompose them into their last elements, and avail himself of these, as he does, for example, when he extracts the sulphur and the metal of an ore, and uses both; or when he takes out of salt the chlorine, and bleaches with it; and the sodium, and makes soap with it. Or he can *partially* analyse them, reducing them from their native great complexity to perfect simplicity, step by step; doing this by steps of different length, and obtaining something useful at each stage. Thus, instead of at once decomposing sugar into carbon, hydrogen, and oxygen, he can stop short of this, and decompose it into charcoal and water; or into alcohol and carbonic acid; or into oxalic acid and carbonic acid; or into the acid of milk (lactic acid); or into the acid of butter (butyric acid); or into manna and gum; or into mixtures of various of these, and of other peculiar and highly-prized products.

Secondly; He can unite bodies, so as to obtain artificially compounds which are rare in nature or difficult to procure. Thus, instead of digging in Illyria for cinnabar, he heats together sulphur and quicksilver, and makes vermilion in England; instead of sending to the Italian volcanoes for alum, he makes it at home from clay and oil of vitriol; instead of burning sea-weeds, in Shetland, to get carbonate of soda, or sailing to India for saltpetre, he produces these at his own door, by uniting their constituent acids and bases. Further, out of the sixty elements he manufactures compounds of the greatest value to the industrialist, which are not to be found in nature at all, such as brass, gun-metal, cast-iron, steel, percussion-powder, bleaching powder, chloroform.

Thirdly; He can take certain constituents from a compound whilst he adds in their place others, so that analysis and synthesis proceed side by side. Thus he removes oxygen from iron ore, and replaces it by carbon, converting thereby the iron into steel. He begins with a carbonate, and replaces the carbonic acid in it by sulphuric, nitric, acetic, or other acids, so as to convert it into a sulphate, nitrate, or acetate. He takes carbon, hydrogen, and oxygen from alcohol, and adds chlorine, transmuting the spirit into chloroform. Such processes of substitution are perhaps the most common of all the transformative methods of the chemist, and they often imply complete exchange among all the elements of very complex compounds.

Fourthly and lastly; He can transform bodies, without taking ingredients from them or adding ingredients to them. By a new arrangement of particles, implying neither loss nor gain of weight or substance, one body may be converted into another of properties totally different. Thus starch can be changed into gum, and gum into sugar, and sugar into wood-fibre. A neutral salt may become a powerful base; a volatile odorous liquid an indifferent crystalline solid. Chemistry looks in no direction more hopefully than in this for new triumphs over matter.

There are thus four means of inducing chemical change, resembling familiar arithmetical processes. The first, a process of simple subtraction; the second, a process of simple addition; the third, a process where certain figures are annexed and others removed; the fourth, a process where, without altering the total number of figures, the value of each, and of the sum total is changed, by changing their relative decimal places.

Astronomy and Chemistry thus stand at opposite poles; although no one who studies both can fail to perceive that the stars of the one science are represented by the atoms of the other, and that it is felt to be as natural to speak of the atmosphere of an atom as of the atmosphere of a star. The ancient vague alliance between astrology and alchemy has not been repealed, but only by wise restriction and enlargement made the modern explicit and intelligible bond between astronomy and chemistry. They agree in being observational and analytical, but differ inasmuch as of the two, chemistry alone is synthetical, synthetico-analytical, and transformational. And although as a science chemistry is not more essentially analytical than astronomy; all the sciences, as already urged, being, according to the limits of their domain, equally analytical; as an applied science, *i.e.*, as an art, its powers of analysis give it pre-eminence. In popular language, this word "analysis" is understood to signify chemical analysis, nor need the analysts of the other sciences complain of this. It is the utilitarian value of the material products of such analysis, not the fact or mode of its performance, that chiefly leads to the appropriation by Chemistry of the term. The analysis by the telescope of the milky way into a firmament of stars; of nebulæ into clusters of them; of one evening star into a Jupiter with four moons; of another into a Saturn with rings; of a third into a double star, with each twin differently coloured, are performances as wonderful as the analysis of water into oxygen and hydrogen, or of vermilion into sulphur and mercury. But the moons of Jupiter have no industrial applications, and the rings of Saturn do not alter in market value; the Milky Way has not become more nourishing since the gods vanished from the sky; nor is a double star of more use than a single one. Microscopic analysis, anatomical analysis, crystallographic analysis, yield results as curious and as important as any yielded by chemical analysis, but they have little interest for the Industrialist. It matters not to the manufacturer of phosphorus what the microscopic characters of a bone are, but a great deal what its chemical composition is. It matters nothing to the farmer what the shapes are of the fossil infusoriæ in the soil he tills, but a great deal what the chemical constituents of that soil are. It matters little to the gunpowder maker what the crystalline forms of sulphur and saltpetre are, but he attaches the greatest value to the question of their chemical purity.

There is another reason why the word "analysis," unless qualified, should be so generally understood to signify chemical analysis. Chemistry, alike as a science and an art, does not merely separate the complex material wholes with which it deals, into their simpler and simplest ingredients, but completely detaches each of these from the rest, and handles it apart. We do not merely know that water consists of hydrogen and oxygen, but these themselves are ours, to examine as minutely as we please. The solitary exception presented by the element Fluorine, which chemical science can logically analyse out of its compounds, but which chemical art cannot concretely isolate and exhibit, makes the contrast in all other cases the more remarkable. No doubt our means of mechanical analysis, and isolation are very great, as geology, mineralogy, anatomy, and physics, generally illustrate. Their modes of application, however, and their results, are less numerous and far less striking than those of chemical analysis. The mechanical part, for example, of metallurgy, with its minings and diggings, its crushings and sortings, its siftings and washings, which are all processes of analysis and isolation, makes no such impression on us as the chemical part of metallurgy, where the blast-furnace resolves iron ore into oxygen and iron; and the clay-still resolves cinnabar into quicksilver and sulphur; and the cupel extracts silver from a mixture of metals. The greater impressiveness of chemical as compared with mechanical analysis, largely depends upon the greate rapidity with which the former can be executed, and its results rendered visible. You let fall a drop of oil on the liquid chloride of nitrogen, and on the instant it is resolved into its component gases. You strike a fulminating crystal, or heat a lock of gun-cotton, and in a moment every element in either is set free. You expose a salt of silver for a second to the sun, and silver appears. You add a little green vitriol to a solution of gold, and the gold is at once deposited. You plunge the poles of a galvanic battery into water, and torrents of hydrogen and oxygen instantly rise from the liquid. No science but chemistry can show such things; and if the practical chemist does not analyse quite so swiftly as such feats would imply that he might, he nevertheless always analyses swiftly. But skill to analyse, forms, as we have seen, but one-fourth part of the chemist's power. He can build up as well as pull down; he can do both at once, and he can transmute without doing either, and all as swiftly as he analyses. This four-fold power and this immense energy place chemistry at the head of the experimental transformational sciences; and render it as an art so mighty in effecting useful changes upon matter. It is the type of the one group of industrial sciences, as astronomy is of the other.

Astronomy is severely observational as a science, and passively registrative as an art. At best it lifts up its hand only to warn, and stretches forth its finger only to point. Chemistry is inquisitorially scrutinising as a science, and actively changeful as an art. It lays its hand upon everything within its reach, and is never content till it has made some alteration upon it. The symbol, accordingly, of astronomy, is an Eye; the symbol of chemistry is a Hand: not that astronomy is handless, or chemistry eyeless; but the power of the former is in its eye; the power of the latter is in its hand. The symbol of industrial science is a hand with an eye in the palm, and the fingers free. Let this be the crest of the Industrial Museum.

The other physical sciences rank between those two, standing nearer to the one or the other, as they are predominantly observational or experimental. Nearest to astronomy stands geology. The magnitude of the objects with which it deals, small though they are compared with those which concern astronomy, places them in greater part beyond human interference. And the same influence which illimitable space exerts in astronomy, by lifting the stars to heights inaccessible by us, immeasurable time exerts in geology, by enlarging her almanac, so that less than a line suffices for all the generations of the most ancient race.

Yet geology is visibly an experimental science, which astronomy is not. Our experiments upon the earth have indeed been more frequently incidental than designed, yet human feet have not trod the globe for thousands of years without leaving foot-prints upon it. And although with all our mines, tunnels, canals, bridges, roads, railways, breakwaters, and harbours, we make no greater change on the crust of the globe than the earth-worms do on the soil of our gardens, or the sea-slugs on the sand of our shores; still, like them, we do leave behind us an impression which is not only immense, as tried by human standards, but sufficient, we may believe, permanently to distinguish our planet from all others. Such determinations, also, as those of the heights of mountains, the depths of oceans, and the limits of our atmosphere: such observations as those of the size, and the shape, and the weight of the earth: such bold questions, boldly answered in the affirmative, as—"Is the sea open to the four winds of Heaven? and may we sail upon it whithersoever we will?: "Is there a great continent to the west of Europe, behind the arch of the sea; a land of gold, near the setting sun? Is the ocean a sphere as well as the land, and may we let loose from our sea-rock without anchor on board, and measure the great circle, floating every day on new waters, till we moor beneath the white cliffs of our sea-rock again?" Such achievements, although a strict logic must refer them solely to observational science, inasmuch as they imply no transformative power over the objects with which they deal, yet include in the instruments with which they are effected, so many fruits of transformative experiment, and are wrought out so thoroughly in its spirit, that we cannot easily reconcile ourselves to calling their heroes simply observers. They plainly deserve a middle place. Geology is half of the heavens: half of the earth. She stands an imperial queen, with her head among the stars, and her tresses are white with the snows of ages; but her feet, graceful and quick, are beneath the young grass, and are wet with the dews of to-day. Her hands are often raised to shade her eyes, as she gazes through space to exchange greetings with each sister-presence in the worlds around. But her fingers are as often busy with homely cares, and with bended forehead she traces for the tenant-lord of her estate the best track for his railway and channel for his canal, and shows him where to find coal and iron, and how to dig for gold. The geologist, indeed, is so essentially a miner, a quarryman, a rock-blaster, a stone-breaker, a hill-climber, and leveller, that we do not realize him without such tools in his hands as to the imagination appear more potential than mere instruments of observation. Geology thus forms a link between the contrasted groups of sciences. It is to some extent experimentally transformational, and will slowly, as the ages roll on, become more possessed of this character. *Registrative,* it scarcely is at all. It does not, for example, warn us of earthquakes, but only tells us when they are past; and we can scarcely call it *Directive.* It is of the greatest importance, however, to industrialism, in its purely observational character, as dealing with the globe as a great store-house of mineral matters of the highest value. I need but name building stones, metallic ores, the constituents of glass and porcelain, coal, and lastly water.

Next to Chemistry, as an Experimental Science, wielding immense transformative power, stands Mechanics. I include under this term the science of force, not only as determining the rest and sensible motion of masses or particles of matter; but also as determining all structural or molecular changes in bodies, whether solid, liquid, or gaseous, which are not produced by chemical alterations, or by the vital agencies at work in plants and animals. Were this identity between mechanical force, and all molecular force which is not certainly chemical or vital, made the ground of positive deductions in natural philosophy, it would be liable to the gravest objections. But, regarded simply as an assumption, awaiting refutation, verification, or correction, as knowledge progresses, it will involve us in no speculative error, whilst it greatly simplifies our study of many of the practical applications of science. There are few technical processes, for example, more important than the tempering of steel, the annealing of glass, and the crystallization of salts; yet how far the structural or molecular changes which it is the object of those processes to produce, imply only a mechanical, or, as is most probable, also a chemical change in the relative arrangement of their particles, is unknown. As however no loss or gain of element or ingredient, or any other *sensible* chemical change occurs, whilst a very appreciable mechanical alteration happens, it is convenient to disregard in technological discussions the possibility of the former kind of transformation occurring, and to recognize the occurrence only of the latter. The relation of vital to mechanical force will be considered hereafter.

The transformative power of Mechanics over matter comes before us as industrialists in a threefold way. First; As furnishing a motive power which can be directed on masses both large and small, so as to throw them into motion. Second; As furnishing a means of inducing change by alterations in the external configuration of bodies. Third; As furnishing a means of inducing molecular change in a mass without alteration of its external configuration or production of sensible motion.

So far as the first is concerned, I need scarcely remind you that there is scarcely an industrial art which does not in some of its departments require a motive power. A steam-engine is scarcely wanting from a single utilitarian establishment. Places so unlike each other as a farm, a dye-work, a cotton factory, a stone-cutter's yard, and a wood-carver's shop, have alike this indispensable engine, or some substitute. This necessity is curiously illustrated by the same word *mill* being applied to industrial establishments of the most opposite character. We speak, for example, of a flour-mill, a cotton-mill, a gunpowder-mill, and a saw-mill. As examples of the application of motive power to the production of mechanical transformation, I shall content myself here with referring to the conversion of wool, silk, flax, and cotton, into woven fabrics, and of rags into paper.

So far as the second aspect of mechanical force is concerned, namely, as an inducer of alterations in the external configuration of bodies, it will be sufficient here to refer to the arts of the stone-cutter and wood-carver, and to those of sculptors, carvers, and engravers of all kinds.

As for the third aspect of mechanical force, namely, to induce internal molecular change, such processes as the tempering of metals, the annealing of glass, and the baking of porcelain, in certain of its stages, may serve as illustrations.

In contrasting mechanical with chemical transforming force, it is curious to notice how in one respect the former is the more imposing, in another the latter. Mechanical force, when exerted as a motive power, can be employed by man on a much grander scale than the similar power of chemical force, except in the case of explosives. Artificial chemical processes, again, on however large a plan they are sonducted, are, with few exceptions, such as that of the iron blast-furnace, striking only in their results. But the movements of massive pieces of machinery, even though moving aimlessly, still more when working for a purpose, always awaken in us the idea of power; and often also create emotions of awe and sublimity akin to those which are begotten by the spectacle of great natural phenomena. The sweep of of a railway train across the country, and the dash of a war-steamer against the waves with which it measures its strength, never become paltry pageants, even though we are ignorant of the errands on which these swift coursers are bound. Still more striking are those actions of machinery which involve not only swift irresistible motion, but also transformation of the materials on which the moving force is exerted. Take, for example, a cotton-mill, which some never tire of representing as dreary and prosaic. In the basement story revolves an immense steam-engine, unresting and unhasting as a star, in its stately, orderly movements. It stretches its strong iron arms in every direction throughout the building; and into whatever chamber you enter, as you climb stair after stair, you find its million hands in motion, and its fingers, which are as skilful as they are nimble, busy at work. They pick cotton and cleanse it, card it, rove it, twist it, spin it, dye it, and weave it. They will work any pattern you select, and in as many colours as you choose; and do all with such celerity, dexterity, unexhausted energy, and skill, that you begin to see what was prefigured in the legend of Michael Scott, and his "sabbathless" demons (as Charles Lamb would have called them), to whom the most hateful of all things was rest, and ropemaking, though it were of sand, more welcome than idleness. For my own part, I gaze with untiring wonder and admiration on the steam Agathodæmons of a cotton-mill, the embodiments, all of them, of a few very simple statical and dynamical laws; and yet able, with the speed of race-horses, to transform a raw material, originally as cheap as thistledown, into endless useful and beautiful fabrics. Michael Scott, had he lived to see them, would have dismissed his demons and broken his wand.

Yet magnificent as the scale is on which many mechanical transformations occur, they are to a great extent undervalued because there is nothing mysterious about them. However great the difference between the raw material and the finished product, we can follow each step in the transition from the one to the other. The Portland Vase, for example, is as different, in one respect, from the ball of vitreous jelly out of which it was elaborated, as in another, that jelly is from the sand and alkali and metallic oxides, which were melted together to produce it. Rarely-gifted hands and nice tools were needed to furnish the mere outline of that beautiful vessel; still more to carve the exquisite shapes which are sculptured upon it. Its materials, on the other hand, are of the cheapest; and the most ignorant slave had skill enough to melt them together. Yet we can realise each step in the mechanical workmanship; and some lookers on; if none others, the artists themselves, saw the whole grow into beauty under their eyes, like Aphrodite rising from the glassy sea. But no one saw or can see the sand and alkali change into glass, or can realise what happens during the transmutation. The most critical part of the process is effected *per saltum;* and, as with children trying to watch themselves fall asleep, our eyesight and consciousness fail us at the very moment when the mystery lies bare, and the secret is open to view. It is so with every chemical process: bleaching, dyeing, fermenting, ether-making, reducing of metals, firing of gunpowder. The substances taking part in each reaction are like masqueraders crossing a bridge, the crown of which is hidden by clouds. You trace them, letting no movement escape you, as they climb from one side leisurely towards the elevated centre, and enter the shadowing cloud, but though it seems quite transparent, its entrants grow suddenly invisible, and when you next catch sight of them descending on the other side, they are transfigured and totally changed.

This occult character of chemical force appeals not only to that vulgar wonder which holds *omne ignotum pro magnifico,* but provokes the chastened curiosity of the philosopher, who cannot divine what or how many unexpected figures may emerge from each enigma, and alter the value of all his calculations.

The mechanical powers are like stalwart giants of Northern blood, standing erect and naked to the waist, with their ponderous tools beside them, and their fair, frank faces, ignorant of guile, opening their blue eyes calmly upon us. They possess only strength and skill, and obedience to laws so few and simple that they can be made plain to any intelligent child. We respect and admire them; but we feel that we can measure their height, and take the girth of their arms, and we are not afraid to calculate the horse-power, immense though it is, which lies in the bend of each of their little fingers.

The chemical forces are like supple Eastern jugglers, with swarthy brows, and lustrous, unfathomable eyes, who never look you straight in the face, or measure glances with you. They are robed in gauze, which seems transparent like glass; but when you try you can see nothing through it. The instruments in their girdles are like children's playthings; and the lighted lamp, which they always keep near them, has nothing to distinguish it from ordinary lamps. You may be indifferent when they stretch forth their slender arms, and ask you for the stone beneath your feet; but you are startled when, after some sleight-of-hand, you receive in its stead a steel blade or a sphere of crystal; and you tremble when you see the cunning fingers close for one moment over a little harmless charcoal and water, and open the next to offer you the deadliest poison. These subtle conjurors, secret as the grave, have we know not what of angelic, what of demonic power at their command; and we are continually tempted to put a higher value upon their mysterious legerdemain than upon the open handiwork of the mechanical powers. In so far, however, as the artificial modification of matter is concerned, we almost invariably require the services of both, and they work willingly together. It may be well to have one word, as *transmutation*, to indicate chemical molecular change, and another, as *transformation*, to indicate mechanical molecular change; but, as industrialists, we must hesitate to marvel more at the one than the other. How cheerfully they labour to a common end, like twin brother and sister; the one strong by measurable strength, the other by immeasurable fascinating power, we see in the case of that great world-changer, that emblem of war, and minister of peace, gunpowder. It needs the strong brother to fell the oaks, and with a hint from his twin to burn them into charcoal. It needs his stout arms to quarry the sulphur, and bring the saltpetre from India; to crush them into grains, and grind them together. But it also needs his weird sister, in whose palm he lays the innocent dust, to breathe upon it before the Alps are tunnelled, or Sebastopol lies in ruins.

It is not necessary, after the division I have made, to make special reference to heat, light, electricity, and magnetism as sciences of transmuting and transforming force, since, without deciding on the essential nature of the agencies which they represent, we may, as industrialists, divide them between mechanics and chemistry. Thus heat may be equally partitioned between them, as alike remarkable for mechanical and chemical alterative power. Electricity and light may be given in larger part to chemistry; and magnetism in larger part to mechanics. On the other hand, also, mineralogy, as a lesser geology, may be ranked along with it.

We may suppose all the sciences related to industrialism arranged in the form of a crescent. At the tip of the one horn stands astronomy, next it is geology, and next to that mineralogy. At the tip of the other horn stands chemistry, next it is mechanics, and next to that heat, light, electricity, and magnetism. In the centre of the crescent stands the remarkable science which we have still to consider, namely, biology. It includes botany, the science of plants and plant life, and zoology, the science of animals and animal life. These sciences, in popular estimation, alone constitute natural history, and are often referred to as if they were solely observational and analytical; but they are transformational in a remarkable way, and furnish the industrialist with most important instruments for effecting changes upon matter. After death, plants and animals furnish to the botanist and anatomist endless subjects for the observation and analysis of peculiarities of form, structure, and function. To the practical chemist also and the mechanician they supply the raw or *genetic* materials, such as wood and wool, of a thousand industrial arts. During life they are likewise objects of observational science; and in one respect are as much removed beyond direct human interference as the objects of astronomy. Life builds up a barrier round plants and animals, which we may not overpass, except at a few places. We cannot experiment on them in the way we can on dead objects; for interference with them, to any considerable extent, either sacrifices life, or so alters its conditions that a dead or diseased thing is left in our hands. Nevertheless every living plant and animal is for the industrialist a machine or apparatus, possessed of remarkable transforming and transmuting powers, which, to a very considerable extent, may be controlled, directed, and even modified by him. And if living organisms cannot be wielded as tools or weapons in the same way as inorganic machines can, there is this great compensation in the fact that, to the extent an organism can be wielded by us, it enables us to add to the transforming and transmuting powers of mechanical and chemical force, which alone are available in the dead machine, the metamorphosing power of vital force. Differences of opinion may exist as to the essential peculiarity of this force, but there can be none as to the practical advantage of regarding it as distinct from mechanical and chemical force. I will go further, and apply the term *metamorphosis* to the kind of change which vitality specially induces in matter, so that, accepting the confessedly arbitrary employment of terms which I have proposed, we shall speak of a mechanical *transformation*, a chemical *transmutation*, and a vital *metamorphosis*.

Looked at from this point of view, biology yields to none of the sciences in industrial importance. Translated into practice, it gives us agriculture, an art so peculiar and extensive, that, like medicine, it demands all the energies of an entire profession. It is not my province to discuss agriculture, but there are certain industrial aspects of the biology on which it reposes, requiring notice here.

Animal force is of immense importance to all the useful arts; first as a motive, secondly as a transformative power. In these days of railways and steam-engines we are apt to think too lightly of our horses and other beasts of burden, forgetting that without them we could not construct the engines which to some extent are supplanting them, and that they themselves are the best of engines for many purposes. James Watt and George Stephenson, I am sure, respected even a donkey; and were the last of its race to die, we might all join Sterne in weeping over the dead ass. We do not sufficiently remember that all other machines are the offspring of living machines. A steam-engine is the literal as well as the metaphorical embodiment of so much horse-power. A railway viaduct is the petrifaction of so much animal force. A power-loom, after its last improvement, remains still a hand-loom. Archæologists tell us, that in far separate regions of the world, you find stamped on the monuments of forgotten races the impression in red of a human hand. But we need not go to distant lands and the works of extinct races for this mysterious signature. The mark of the red hand, red with the blood which toil has wrung from it, will be found on every industrial instrument and product, and the print of a horse's hoof is generally near it. A horse's shoe, indeed, might be nailed up on many a door besides the blacksmith's, to keep away the evil spirit of idleness, if we are afraid of no other demon.

It is only the sentient organism, the animal, that has motive and transformative powers of the kind we have been considering; and it is only the paragon of animals that is able to direct them at will. But a transmuting and metamorphosing power of another kind, and not less important to industrial art, is common to plants and animals, and in some respects characterizes the former even more than the latter. The plants and animals which as agriculturists we care for, may be regarded as skilled labourers, who in return for food, wages (which must be paid in kind), and a certain liberty of action, agree to collect or manufacture for us a multitude of useful substances. We employ them, and many wild plants and animals also, as collectors or amassers of certain bodies, because although we could collect these ourselves, we could not do it half so well. We employ them as manufacturers, because they keep their processes secret and have a monopoly of the manufacture.

Look first at their skill as collectors. As soon as the seed we sow has germinated, it begins to extract from the soil, or water and air around it, various matters, among others the mineral alkali, potash. Now this alkali is of great industrial value, and it is in our power to procure it from the sources which yield it to plants. To procure this, however, is a tedious, costly, and laborious process, for all the free alkali to be found at any moment in a moderate weight of soil is exceedingly small, and could not profitably be extracted by any artificial method. But a growing plant, day by day appropriates to itself an almost infinitesimal amount of potash through its roots, and like a miser hoards it all, or nearly all, so that if at the close of a season we burn it entire, we find in the ashes all the gathered potash of the year harvested to our hands.

The sea, in like manner, is the great fountain of a rare and prized substance, iodine, but were we compelled to take it directly from the ocean we should require to evaporate tons of water to keep a single photographer supplied with it, and it would be more costly than gold. But the seaweeds employ it as well as the photographers, and have long anticipated the physicians in taking it internally. Day by day they sip a homœopathic dose of iodine and retain it, and by and by we burn them into kelp, and extract iodine and much else that is valuable from the ashes.

To take another example, phosphate of lime, a minute constituent of all fertile soils and of most waters, is of great value to the ivory-turner, the manure-maker, the potter, the silver-assayer, the drug-manufacturer, the dyer, and the lucifer-match maker. It reaches all of them in the shape of the bones of dead animals; dead cattle from our farms, dead horses from the Pampas of South America, dead walrusses from the arctic icebergs, dead whales from the Pacific Ocean, dead men even from fields of battle. Land and sea plants have, as it were, milked this essential constituent of their frames, drop by drop, from the breast of nature. Animals of all classes, from the lowest to the highest, have robbed plants of their hard-gotten gains, and made their bones strong with the precious substance. Finally, the chartered robber man has robbed them all, claiming even the relics of his brethren, and obtaining in a handful of bone-dust the phosphate of tons of rock and water.

The industrial importance, however, of plants and animals, as collectors and harvesters of valuable mineral matters, is insignificant compared with their value as manufacturers of bodies whose worth depends much more on their construction or composition than on their raw material. In their former capacity, living organisms resemble simply filters with apertures of different fineness, and fitted to arrest and detain certain substances in themselves valuable. In the latter, those organisms resemble highly complex machines, able to convert the most familiar things into substances precious almost solely from the workmanship bestowed upon them.

Take for example that important substance, wood. Its chief ingredients, charcoal and water, are uncostly and abundant; but in themselves they are useless to the carpenter, and he cannot change them into timber. So he calls to remembrance that his great grandfather planted an acorn, which has turned its first small capital to so excellent account that now it is a timber merchant on a large scale, and will contract with you to build a ship of war out of oak of its own making. It is with other trees as with this ancestral oak. Each, with its republic of industrious roots and leaves, is a joint-stock company with limited liability, engaging to furnish you with pine-stems for masts, fir-wood for planking, logwood for dyeing, cork bark for bottling, oak bark for tanning, walnut for tables, rosewood for picture-frames, satin wood for looking-glasses, willow for cradles, mahogany for wardrobes, ebony for will-chests, elm-tree for coffins.

Those trees form the Worshipful Company of Woodmakers, an ancient guild. But there are others as old. A peaceful army of flax plants protects the monopoly of linen-weaving. Whole battalions of cotton shrubs watch over calico. No one may infringe the patent of the indigo plants for blue dye; none may borrow the multitudinous crimsons and purples of the madder root; none may rival the elastic fig in manufacturing caoutchouc; or learn from the trees of Siam how to produce gutta percha. The roses of Damascus keep the secret of their otto to themselves; and the acacias of Arabia alone deal in gum.

Each of those plants has a monopoly of its manufacture, and sells, at a price settled by itself, all that it produces. The charge is entirely for work, not for materials. You may bring these, indeed, yourself, and have them made up for you;

and nearly the same materials will suit all the manufacturers. The cane will return them as sugar, and the vine as grape-juice, the olive as oil, and the poppy as opium; keeping only to themselves such a percentage as is needed to maintain their workshops, and multiply their buildings. The day *may* come when the patents of these monopolists will expire, and their secrets be published recipes open to all; but that day is far distant, and chemistry as yet has discovered only so many of their devices as serve to whet to a keener edge her unsatisfied envy of their unapproachable powers. Plants are thüs, in virtue of their amazing ability to convert the simplest and commonest ingredients of air, earth, and water into the most complex and precious compounds, of as much value to the industrialist, considered simply as pieces of apparatus, as the most elaborate engines he has constructed. Nor is it otherwise with animals. They do not work with so simple a raw material as plants do: they use plants, indeed, directly or indirectly, as their raw material; but they convert them into products raised in industrial value by the additional workmanship bestowed upon them. We have thus the silkworm, whose calling it is to turn mulberry leaves into silk; the bee, who turns sugar into wax; the coccus, who turns cactus-juice into carmine; the oyster, who turns sea-chalk into pearls; the turtle, who turns seaweeds into tortoiseshell; and the whale, who turns sea-jellies into oil and whalebone. The birds are the only makers of quills and feathers; the hogs of bristles; the elephant, the walrus, and hippopotamus of ivory; the sheep of wool, not to speak of fat and mutton; the ox and his congeners of undressed leather; the beaver and his brethren of hat-felt; and myriads of wild creatures of land and sea of furs and skins. I have barely alluded to one animal, as supplying us with food; although, as I need not remind you, the most important industrial relation of many others is their power, as machines, to convert weeds of various kinds into beef, mutton, venison, milk, butter, eggs, the flesh of birds, and beasts, and fishes.

Two points call for special notice in connection with living plants and animals, as industrial apparatus and machines. Firstly: It is impossible ever to say too much regarding their amazing transforming, transmuting, and metamorphosing powers. Into the question how far their functions, as modifiers of matter, depend upon their vital, as distinguished from their mechanical and chemical endowments, it is unnecessary to enter here. It is sufficient to notice that the power which every blade of grass and green leaf possesses to resolve carbonic acid into charcoal and free oxygen, and thereby to build up the most solid vegetable tissues, chiefly out of air, is beyond the rivalry of all our engines; and this is but one feat among the thousands which plants unconsciously perform, and in vain bid us repeat. Within the more complex region of animal life, we are equally compelled to be mere spectators of changes of matter which we very imperfectly understand, and cannot effect by our machines. We can scarcely, accordingly, rate too highly the importance of living organisms, as working for us and with us. Secondly: Although we cannot construct machines to rival sugar-canes and silkworms, or any other plants and animals, we have a singular power of modifying these, so as to alter their actions as machines.

At every agricultural show, prizes are given to the exhibitors of vegetables and animals, which differ as much from their protoplasts as Watt's steam-engine does from Savary's or Newcomen's. So much has cultivation changed our most highly-prized cereals, that it is matter of dispute from what forgotten weeds wheat and barley, as we now see them, have been elaborated. Our apples and pears were once sour crabs; our plums austere sloes; our turnips acrid radishes. We have as truly created such fruits and vegetables as the chemist has created ether or chloroform. The physiologist, no doubt, is much more limited than the chemist as a creator, but he is as truly one. Both work under that aphorism of the *Novum Organon*, which teaches us to conquer nature by obeying her.

The creating power of the physiologist is still more striking as exerted upon animals. Our dogs, and horses, and cattle, we have *made*, as truly as we have made glass, or bronze, or porcelain. Nature yields no pointers among dogs, or race-horses among steeds, or short-horns among cattle. Food and climate, regimen and temperature, domestication and training;

above all, pairing in special ways, have given us endless and important varieties of every creature we have cared to subdue; and whenever the whim prompts us to make pets of pigs, or rabbits, or pigeons, we shew through how many phases we can induce our playthings or victims to pass.

We do not generally call this *creation*, because we quickly realise that we are but evolving certain germinal tendencies latent in the plants or animals whose offspring our interference renders so unlike themselves; but we do no more when we call into existence glass or ultramarine; for unless the elements of these compounds had inevitably tended to produce them under the conditions which we secure, the securing of these conditions would no more have produced them than the mating, under certain restrictions, of particular vegetable or animal pairs would have given us the grapes of Portugal or the race-horses of England.

But whether we choose to call it creation or not, it is transformation of a kind as important, industrially, as that which mechanics has effected on many a machine. Ask a baker if he sets the same value on samples of wheat differently derived and grown, and he will offer you twice the sum for one that he will give for another. Ask a brewer the same question regarding barley, and you will receive the same answer. The sugar merchant carefully classifies his beet-roots or sugar-canes, the perfumer his lavender and orange-flowers, the wine maker his grapes, the tea-merchant his teas, the dye broker his indigos and madders, the pharmacologist his poppies and cinchonas. The plants in which those industrialists have an interest may, by variation in stock, in soil, latitude, climate, mode of cultivation, degree of manuring and the like, be made abundant or deficient in starch, sugar, azotised nutritive principles, mineral salts, odorous essences, colouring principles, and medicinal or poisonous alkaloids.

It is the same with animals. A cattle-dealer will give you one calf which shall certainly in course of time prove a bountiful yielder of milk and cream; another which shall as certainly be a fatted ox when three years old; a third which shall by and by be a match for a horse at the plough.

A jockey may at first stun you with what seems his unintelligible slang about blood, and bone, and wind, and bottom; but by and by you discover that these are his technical phrases for certain structural and physiological peculiarities, which he can exalt or diminish in a particular animal by due selection of sire and dam, and fit treatment, and training of foal; so that if you are not very difficult to please, and, moreover, are not in a very great hurry, he will contract *to make* you a horse according to the pattern you select, as an engineer will to make you a steam-engine.

So also: The Yorkshire broad cloth makers choose by preference the long stapled wool of sheep fed plentifully upon artificial grasses, turnips, and the like. The Welsh blanket-makers, on the other hand, prefer the shorter wool of sheep cropping the natural grass of the hills; whilst the Scotch tartan shawl weavers work only with Australian or Saxon wools.

In like manner the comb-makers will tell you that the farmers are injuring them, by multiplying breeds of cattle which quickly fatten, and are, in consequence, killed before their horns are well grown; and those same industrialists will curiously distinguish between the tortoise shell from one region of the sea and that from another.

I should never end, were I to pursue this matter. Let those illustrations suffice to show that living organisms are not only industrialists like ourselves, and in many cases more skilful artists, but are also machines and apparatus which, within certain wide limits, we can wield at will.

Such, then, is the scientific basis of industrialism, a platform broad as the whole earth, and reaching even to the stars. Although to biology we give a special place, because it deals with the inscrutable mystery of life, yet after all we can find room for it in the twofold division of physical sciences which arranges them, as each in part passively observational, in part actively transformational. Our whole work, as industrialists, resolves itself into observing and transforming, and whether we labour as observers or transformers, we have noble work to do. In either case, an edifice rises before us as the fruit and memorial of our labour. In the one case, this edifice is like a Nineveh recovered from oblivion; in the other it is like a Crystal Palace, for the first time given to the world. When we work as naturalists, though we do no more than bring into view objects which, from the moment of their creation, have been within reach of our senses, we are, nevertheless, like those skilful excavators who read a new lesson to the modern world, when they recovered to the light of day the long-buried and forgotten wonders of Herculaneum and Pompeii; or like those unwearied explorers who displaced the sand under which Egyptian temples had been concealing, untarnished and unworn, the paintings and sculptures bestowed upon them centuries before. The same kind of interest which attaches to Belzoni, Denon, and Lepsius, as uncoverers of the sand-hidden pyramids and sphinxes of Egypt; and to Young, Champollion, Rosellini, and others, as decipherers of the hieroglyphics upon them; or to Layard, as a revealer of the disinterred wonders of Babylon and Nineveh; and to Rawlinson, as an interpreter of the Cuneiform inscriptions upon their buildings; attaches to the naturalists of all classes. The most ancient book, it has been finely said, is published to-day for him who reads it for the first time. Herculaneum, Thebes, and Nineveh were as great novelties on the day of their re-discovering as if they had been cities of the Mormons, built yesterday. Hieroglyphics and Cuneatics are, for the novice who encounters them, marvels as astounding as the new language can be, which a tribe of native Africans are asserted (I fear on doubtful authority) to have recently constructed for themselves. And so, although Galileo only discovered the moons of Jupiter, we often and unconsciously think of him as if he had been their creator, and had first set them to play their untiring game of hide-and-seek round the stately planet; and so also in no irreverent spirit we call the laws which Kepler divined to regulate certain movements of the heavenly bodies, "Kepler's Laws," although he disclaimed the title, grandly affirming that God, whose laws they were, had waited some thousand years before one man, even Kepler, had discerned them. And so again, notwithstanding our conviction that the star Neptune has been shining in the sky since what I shall be content to call "the beginning," and that all the tiny planets which have so rapidly been added to our astronomical catalogues are probably as old as the sun, we cannot help feeling as if

Adams, Leverrier, Hinds, and their brethren, had just planted those lights in the sky, and that midnight should be sensibly less dark because of their addition to the heavens. I have taken these illustrations from the most observational science, astronomy; but any other science would have yielded illustrations as striking. The mastodons and megatheria of geology pass with us for creatures more recent than the elephants and camels which were the largest quadrupeds known to our fathers. Coal we think of as a newly invented, not as the oldest fuel; aluminium we deliberately call a new metal, although we know none older; and gutta percha is a new "gum." After all, however, the naturalist is but a disinterrer, his tool is a spade, and his newest things are generally nature's oldest, and have taken longest to find, because they were buried first and deepest.

When we work as transformationalists we are like sculptors, not evolving a pre-existent statue from a concealing mass, but bestowing a statue on a block of marble. The hollow screw is Archimedes' screw; the condensing steam-engine, Watt's engine; the railway locomotive, Stephenson's locomotive; the electric telegraph, Oersted's telegraph; the Crystal Palace, Fox and Paxton's palace. Yet as implied in what has been already said, we treat discoverers as if they were inventors, and to make amends we call inventors discoverers. And although, in strictness of speech, it is inadmissible to speak of Watt, as accomplished men are frequently found doing, as the *discoverer* of the steam-engine, and only Sancho Panza thought of invoking blessings on the man who first *invented* sleep, still the popular confusion between the discoverer and the inventor shows how difficult it is to assign the one higher praise than the other. It is better to decline answering, or to leave each person to answer according to his taste, such questions as, Is the world more indebted to Layard, who recovered Nineveh, or to Paxton, who created the Sydenham Palace? Whether industrialism is more indebted to the naturalist or to the experimentalist, is a problem best disposed of by the logic of the child who, when asked whether he would have an apple *or* an orange, held out each hand and replied he would have *both*.

On the Structure and Habits of the Slow-Worm, (Anguis fragilis, Linn.) By DANIEL R. RANKIN, Esq., Carluke.*

From what is recorded in works of reference, the slow-worm (*Anguis fragilis*), though the most accessible and easily managed of the reptile kind, seems to have engaged the particular attention of few naturalists.

During several years, from daily observation of many individuals of uncertain age, and in every stage of development, from the egg till the seventh year, having accumulated a conderable number of facts regarding the economy of this interesting little animal, I am enabled to give some details which may serve more fully to elucidate its history.

The generic position of the slow-worm is well determined; but as general descriptions seem to have been drawn from limited sources, from young or mutilated specimens, or from individuals in some phase of periodic change, confusion appears to exist; and in other particulars there is uncertainty or error.

To secure clear and distinct delineations of objects in natural history words are seldom adequate; but as the aspects of this animal, within description, may be better given if spoken of under divisions, that method shall be followed.

1. *Form.*—The mature animal, as it is found in Clydesdale, is from 17 to 20 inches in length, and attains to this about the fourth, although its other dimensions are not fully reached till about the seventh or eighth year. It has a small, elongated, somewhat angular and conical head; mouth of almost equal length with the head; eyes lateral, oval, distinct, though not prominent; ruby iris; eyelids, and a moveable membrane within eyelids (*membrana nictitans*); nostrils lateral, directed vertically, and situated in the second scale of the second row of the marginal labial scales of the upper jaw, the scale being reflected into the aperture. The neck is short, and at times is observably smaller than the head, as in the act of inspiring, drinking, &c. The body from the neck gradually swells to the middle, then gradually declines in thickness to the cloaca, and from thence becomes smaller and

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* Read at the Royal Physical Society, 26th November 1856.

smaller to the extremity of the tail, which ends a little short of a minute point. A specimen before me, a female fourteen years old, measures 14 lines ($1\frac{1}{6}$ of an inch) round the largest part of the head; at the middle of the body, or about 4 inches from the head, it measures 25 lines, and above the extreme point of the tail it measures 5 lines. The head is $\frac{1}{18}$ part of the whole length—the body, including the head, being about 8, and the tail about 9 inches. These proportions produce a form by no means repulsive, if the word elegant is objectionable as regards a crawling thing. The animal is not therefore "alike thick from neck to tail;" nor does the tail end quite bluntly," according to stereotyped descriptions. Young animals of the same, or of greater length, are more slender; those, for example, of the first year are from 13 to 14 inches long, although so slender as to bear the proportions of a large earth-worm, the head and body being of nearly equal diameter, and the tapering tail slightly smaller. A specimen of the fourth year, still of slender proportions, measures $17\frac{3}{4}$ inches, and one of the seventh year bears nearly the same proportions as the more aged animal before alluded to. After the first year the growth is more to thickness, in proportion, than to length. When observed carefully the body seems somewhat four-sided, and not strictly round—an aspect which the colours of the different quarters tends to favour.

2. *Colour and External Markings.*—The upper part (back) of the head and body, in the mature animal, to the extent of about a fourth of the diameter, is generally of a lustry yellowish-brown marbling; each side to the extent of one-fourth is of a blackish chequered gray, in some instances more intensely dark than in others, excepting on the sides of the head and neck, which is a kind of mottling of lighter colour on a dark ground, the remaining fourth or belly being of a bluish-gray. In passing from the back to the head there is a narrowing of the lustry part, which again swells out anteriorly. Two black spots mark the head—one commonly on each of the larger vertical scales, and in the posterior spot there is an opaque whitish point corresponding with a small opening in the skull. A black zig-zag line passes down the back, dividing equally the bright yellowish-brown part from the

posterior central scale of the head to the point of the tail. In some instances this line is more of a dovetailing character; in others, there are parallel lines or dots, giving the appearance of three, five, and seven lines, in different specimens, and in many the centre line is entirely absent. Among eighteen specimens examined at the time of writing, seven only presented the single central line down the back, which, nevertheless, is the prevailing form. In the young, on leaving the egg, and for some time after, the colour of the back is generally hazy yellow, with, in most instances, a straight black line down the back, while the under three-fourths is glossy black. But from the first there are distinct and numerous varieties of external markings. In an animal, under observation, three years old, the characteristic centre line is wanting; but the yellowish-coloured part of the back is traversed by several faint dark interrupted stripes, and on each side the scales of the fore-part of the body are beautifully marked with spots, each of which consists of a dot of green and a dot of black. In another, sixteen months old, also without the centre line, interrupted dark spots pass down the body, and the scales of the tail are each marked by sometimes two and sometimes three dark streaks, which gives the tail a striped appearance. In another specimen, two years old, there are not only three black lines down the back, but between each two others less dark; and these do not by any means comprise all the varieties of external markings.

But difference of age, or exceptional markings, do not sufficiently compass the aspects of the animal, for the approach of the sloughing periods, which are frequent, very materially alters the appearance alike of the young and old.

3. *Dermal Covering and Sloughing.*—The common notion that a serpent "casts its old skin" once in the year does not hold good as regards the slow-worm, though this is stated by most popular writers. The dermal covering of this animal, unlike that of serpents, but like some other reptiles and fishes, is a beautifully arranged system of plates of bone on which the scales or cuticle repose. These, what I shall call scale-plates, are permanent, and grow with the animal; the scales, on the contrary, are frequently renewed, particularly during the growth of the animal. A specimen, in its eighth year, fed

regularly throughout the whole period while its own dormancy allowed, and while slugs or worms could be procured, sloughed ten times, and in the following year nine times; and this seems, from a large average, to be a common result. In three years one young animal sloughed thirty-four times, and another thirty times. In the first year of rapid growth one sloughed thirteen, and other three twelve times.

The following table gives the exact dates of sloughing of four specimens hatched 3d September 1845, which were easily distinguished, and known by the names heading the table:—

Sloughs.	Spotty.	Spotless.	Spot.	Mag.	Sloughs.
	1845.	1845.	1845.	1845.	
1	October 13	October 13	October 15	October 11	1
2	November 4	November 5	November 13	October 28	2
3	December 9	December 13	December 14	December 7	3
	1846.	1846.	1846.	1846.	
4	January 29	February 1	February 4	January 24	4
5	February 20	February 25	February 24	February 14	5
6	March 14	March 16	March 26	March 6	6
7	April 5	April 11	April 19	March 30	7
8	May 4	May 6	May 9	April 25	8
9	May 28	May 30	June 1	May 11	9
10	June 25	July 1	July 2	June 12	10
11	July 23	July 26	July 28	July 9	11
12	August 13	August 19	August 26	August 1	12
13	September 14	September 27	September 27	September 3	13
14	October 16	November 8	October 30	September 22	14
		1847.			
15	November 4	February 24	November 23	October 14	15
			1847.	1847.	
16	December 21	March 27	January 5	January 14	16
	1847.				
17	January 24	April 23	February 1	February 23	17
18	February 27	May 15	March 1	March 25	18
19	March 23	June 13	March 28		19
20	April 15	July 25	May 15		20
21	May 26	October 3	August 16		21
22	June 21	October 27			22
23	July 26	November 19			23
24	September 13	December 15			24
		1848.			
25	October 28	February 9			25
26	November 24	March 5			26
	1848.				
27	January 9	April 1			27
28	February 2	April 28			28
29	April 10	May 1			29
30	May 22	September 7			30
31	June 22				31
32	July 19				32
33	August 13				33
34	September 14				33

The process of sloughing is very interesting. Eight days usually, but from eight to ten days, before an animal throws off its scaly covering it assumes a peculiar opaqueness, and seems less active. On the fourth or fifth day the original colour is gradually regained, but with less of brightness, and perhaps of a darker shade. On examination about the eighth day, the scales will no longer be found attached to the scale-plates, and the creature is restless. It rubs its head on the grass in the bottom, or on the sides of its box, first on one side, and then on the other, with the evident object of detaching the jaw scales, which it ultimately effects; and so soon as this is the case, the rest of the process may be, and is, performed with apparent ease by muscular action entirely. The scales of the upper jaw being thrown up, and those of the lower jaw down, the head is jerked from side to side till the scales are relieved. A peculiar vermicular action of the body is instituted and kept up, every movement having the effect of gradually sliding the scales back upon each other. But this action does not seem to be entirely local, or directed in such a way as to remove the scales by gradation from the head backwards only, for the action is simultaneous throughout the entire length of the animal. The scales covering the cloacal valve are often carried, by the action alluded to, perhaps an inch backward—by extension—before the head scales are even free, and the scales of the extreme part of the tail are already, it may be, detached from the animal to the extent of from one to two and a half inches when the upwrinkled slough reaches the extremity. An example of sloughing, which, in one well-observed instance, began at the head and cloaca at the same time (from the scales giving way and separating at that point), more clearly illustrates the peculiar action, for each portion moved backward, as if each had been an independent slough.

The time occupied in sloughing, that is from the moment the scales become detached from the head till thrown off, occupies variously from one to two and a half hours; but with assistance, or, perhaps, with such aids as the animal might seek in a state of freedom, the process may be very quickly completed. So soon as the head scales are free, if the animal be taken in the hand and allowed to urge itself through the fingers, placed in such a way as to keep back the scales, detachment is effected in a few minutes—the animal, in apparent ecstacy, working its way out of its skin with elevated head and with lightning-like rapidity, playing, in its characteristic way, its long nimble tongue. But there are states, either of the animal itself, or arising from its treatment, when sloughing seems difficult; the scales seem too dry, are comparatively inflexible, and remain about the body in rings and shreds till bit by bit they are detached.

4. *The Slough.*—The slough, as thrown off from the body, is a mass of scales—not huddled or inverted, but regularly laid one upon another and compacted into a very small space—an inch or two of the tail portion generally remaining free. When newly detached, the slough may be drawn out to fully one and a half the length of the animal. The scales of the head, which are smooth and very varied in size, are so arranged on the upper jaw as to admit of no extension, while those of the under jaw, with the exception of two rows of small scales which cover the bone, are like the other body scales. The largest scales of the animal are the central ones of the head, and those within the angle of the lower jaw, and the smallest are those of the labia, and of the eyelids. The scales of the body, individually, are also smooth, somewhat rhomboid, and collectively are arranged in an imbricated manner, each being encroached upon and encroaching to the extent of one-third, and each having connection with three above and three below. The point of connection one scale with another is the upper border, and each reposes on its scale-plate, the edge of the scale extending beyond the plate; and the whole is united by highly elastic tissue, an arrangement which admits of great expansion and flexibility.

The usual method of enumerating the scales of snakes is scarcely applicable to this species of reptile, for the scales of the entire body, unlike most serpents, are of uniform character. Counting from the margin of the upper jaw along the back, there were, in a specimen carefully examined, 273 rows of scales in the whole length of the animal—7 in the head, 266 in the body and tail, inclusive of the conical scale which terminates the tail. Counting the scales from the under side, there were in all 278, or five more, the excess being in the lower jaw. From the margin of the lower jaw to the verging scales of the cloaca there were 137, and from this to the point of the tail 141.

The valve of the cloaca, situated near the middle of the body, produces no interruption of the symmetry, or of a continuous declination, and, indeed, it would be difficult of detection by those who are unacquainted with the structure of serpents. It is a semilunar flap, so to speak, opening transversely, two scales deep, and fringed by six scales, which are adjusted very perfectly to the scales of the tail. A reflection of the cuticular tissue lines this flap, forming on the upper or body side distinct minute scales, merging in a highly elastic network-like structure, which surrounds the cloacal aperture, and is attached below to the marginal scales of the flap. This reflected portion of the scales is always thrown off as part of the slough, and is seen as a sort of pouch in prepared sloughs.

The colours of the animal are derived essentially more from a sort of pigment which covers the scale-plates than from the scales themselves; still, most sloughs have faint brown streaks on the back scales, and the side ones are sometimes tinged of a slight dusky hue; but the scales of the belly, which look dark when in connection with the animal, are always colourless when detached from the body.

The scales and scale-plates are arranged in rows disposed backward from the centre line of the back in an angular manner. There are, however, instances of imperfect rows—a sort of indentation of a partial row, as if to meet some requirement of contour or function.

The rows are, as a rule, of equal numbers, from 28 in the neck to 2 in the tail; but in every animal there are a few unequal rows, and the tail ends with a single conical scale.

The scales in the upper jaw number	160	
In the under jaw	117	
	——	277

						277
In body there are	23	rows of	28	scales	644	
...	3	...	27	...	81	
...	33	...	26	...	858	
...	29	...	24	...	696	
...	3	...	23	...	69	
...	27	...	22	...	594	
Ending in cloaca	5	...	16	...	80	
					——	3022
Below cloaca ...	13	...	14	...	182	
...	3	...	13	...	39	
...	60	...	12	...	720	
...	7	...	11	...	77	
...	43	...	10	...	430	
...	8	...	9	...	72	
...	4	...	8	...	32	
...	1	...	7	...	7	
...	2	...	6	...	12	
...	1	...	2	...	2	
...	1	...	1	...	1	1574
					——	——
						4873

This is the result of the examination of only one individual.

Of the body scales, those of the neck are smallest and most numerous, admitting consequently of considerable expansion—a condition particularly suited to the requirements of the animal, which swallows its food entire, and often gorges slugs of a size greatly disproportioned to its apparent capacity.

Though not very evident to the eye that the scales of the body differ much in size, the fact is established. In a slough minutely examined, there were in one portion of the body 29 rows of 24 scales each; at the upper part it measured 22, and at the lowest 20½ lines. Above the cloaca there were found 27 rows of 22 scales each; at the upper portion it measured 20½, and at the lower 17 lines. In the tail there were 60 rows of 12 scales each; the upper row measured 14, and the under 12 lines. Still lower in the tail there were 43 rows of 10 scales each, the upper row being 12, and the lower 8½ lines. In sloughing, all the scales of the body are thrown off, including those of the eyelid; but the eyeball does not, though a common belief, cast a film as part of the slough, as occurs in serpents.

5. *Fragility.*—Nature, always bountiful in her provisions for defence or preservation, has given to the *Anguis fragilis* one which, if repulsive to mere observers, is no doubt that best fitted to its peculiar character. It does not bite, at least

in no instance, during years of daily handling, did I ever observe the slightest approach at defence by this mode,—motion is comparatively slow—and it has no adequate defensive armour. The animal must seek its food; but this is generally done without much exposure, for it feeds on slugs, &c., found low in the grass, where, too, from its mode of progression, it is most active and powerful. Sometimes, however, it is found extended as if basking in the sun (probably while incubating, if the phrase can be sanctioned) on sand-beds, or on cultivated ground, helpless, in a great degree, from the want of aids of motion in such situations, and consequently is an open prey to the enemy. But whether in the grass, or thus exposed, it is easily found by the sparrow-hawk (*Accipiter fringillarus*), its most conspicuous foe, which, at the season of the activity of the reptile, may be frequently observed hovering on wing above the sloping banks facing the south, where the animal is most plentiful. When once marked, escape is scarcely possible; but the provision alluded to affords considerable immunity from attack. If the bird seize its prey at any point below the cloaca, the reptile has the power of sundering the part with apparent impunity, and escapes; and if in any way forewarned of danger, the retreat of the animal to the nearest crevice would favour the probability of such a result. Many mutilated specimens are found; and it is scarcely possible to keep numbers that are subjected to daily examination without being a witness to the act which instinct prompts, and which seems to cause little pain or inconvenience. There are sure grounds for affirming that the "breaking in two" of authors is limited to the tail. If violently seized by the body, the tail is, nevertheless, the part thrown off. When a part of the tail is separated from the animal by its own efforts, there seems to be no laceration of the structures, if the vessels and cellular tissue are excepted. Not a scale is torn. Eight conical processes (four pairs), with interspaces between each, projects from each severed part, and each projection consists of one-half of a short muscle which fits or dovetails into each other. The body part has the ball, and the tail part the socket, of the vertebræ. So easy and harmless does this act of the animal appear, that it may almost be classed among the functions.

6. *Reproduction of Parts.*—No sooner is the animal subjected to mutilation than the reparative, and to a certain extent reproductive, process, is instituted. If the loss has been the result of the instinctive efforts of the animal, the parts seem very rugged and irregular, though, on examination, a sort of three-fold dislocation is found to have taken place—scale from scale, muscle from muscle, vertebra from vertebra. As in other animals in similar circumstances, lymph is thrown out, which at first covers the stump, and from day to day is added to till there is a prolongation of a conical form to the extent of about half-an-inch, the reproduced part varying in length and form in almost every case—a result depending, apparently, on the stage of growth at which the animal has arrived. This new structure is at first covered by an imperfect envelope, which comes off with the slough; but in the course of time—from four to six months—scales are formed, and the reproductive process is at an end. In the case of an aged animal the reproduced part, at 3 inches below the cloaca is 5 lines; and in a younger specimen, at 2 inches below the cloaca, the reproduced part is 7 lines in length—the first being composed of seven rows of scales, and the other of ten rows, including in both cases the terminal conical scale. The scale-plates and scales of the reproduced part are comparatively strong, small, and numerous. In the first case the part was separated where the scales are ten in number in the circumference of the tail—the new scales, at the point of union with the old, are twenty in number; in the other case the scales at the severed part are twelve—those of the reproduced portion, at the point of union, amount to eighteen. Vertebræ are not reproduced.

7. *Gestation and Hybernation.*—The periods of hybernation and of gestation of the *Anguis fragilis* I have never been able to determine by the closest observation. The artificial method of keeping reptiles necessarily adopted by the naturalist for acquiring a minute knowledge of their habits, is not the best for all purposes. The more equal temperature

of a house, and confinement in boxes, are alike unsuited for successful results. In all instances, in the natural state, hybernation must vary with the setting in of winter and spring respectively. As to gestation, if the reptile, in this country, has only one set of young in the year, which I am disposed to believe, and granting that it follows other cold-blooded animals, to which it has some affinity, in making the reproduction of species its first effort after the slumbers of the winter; and granting, also, that it has been rarely found in activity in Clydesdale earlier than the middle of April, I would be disposed to fix about four months as the period of gestation; because, in every instance within my observation, the impregnated specimens found produced their young or eggs late in August or early in September.

On 3d September 1845 a litter was hatched all but under my own eye, and I had the parent in my possession from the preceding June. On opening the box in which it was confined, I found seven young in great activity, with the fœtal vascular tissues still fresh, attached to the cloacal valve, and four eggs, membranous oblong bodies, little larger than a field bean, three of which ultimately yielded their living contents, and one remained entire with the young one visible within. The young at this stage of existence were from 33 to 36 lines long, not thicker than a small earth-worm, and weighed from 11 to 13 grains. In this way I became possessed of ten objects of special interest. During the first day, one was, no doubt, devoured by its parent, for I found half of the tail unconsumed, which the little creature had in all probability wriggled off in an instinctive struggle. On procuring small slugs, the young reptiles pounced upon them with artful avidity; and so voracious were they, that one of the slugs provided for the old animal was seized upon, although ten times the weight of the creature that made the bold attempt. It was amusing to see the slug moving on in its even course with the slender reptile attached, tugging in vain for the victory. Though all did not grow equally, they on an average gained about an inch in length, with a proportionate growth otherwise, monthly, for the first year. Among my stock I frequently had aborted eggs, apparently all yolk. In spring, these inoffensive reptiles became among themselves pugnacious. Two individuals, in particular, I had frequently occasion to separate from what appeared a death struggle; and as the violence was, in a sense, exceptional, I considered the *causa belli* to be sexual.

8. *Feeding, Motions, &c.*—This reptile shuns the light, and is often found in long grass, or under the new laid swath, where food is likely to be found. In seizing its prey something like a display of strategy is made. The object is marked, the animal hovers over its victim, arches its neck, and ultimately, though the action seems unnecessary, darts upon it. Whatever is seized is gorged, and apparently all but impossible masses are swallowed. I have seen—besides slugs, which it seems to prefer, and worms which it feeds on readily—very small frogs and toads, and also caterpillars, to which it was restricted, taken; and I have good grounds for believing that its own young are not rejected. The manner of seizing its prey would suggest that it has to deal in a state of liberty with animals more active than the snail or worm. The gorging process is slow but certain; the snail being caught, the slow-worm rests for a considerable time, when a sort of convulsive opening and shutting of the jaws take place—a pause and similar efforts occurring at what seems measured intervals, till the object disappears within the jaws. A circumstance which long puzzled my discerning powers, may be worth notice: I remarked that the bulging mouthful, made by a large slug, acquired a singular impulse inwards each time the mouth was *opened*, and that although the mouth was opened comparatively slowly, an instant snap succeeded, as if to make good the advantage. After careful watching, and a thorough examination of the machinery, I came to the conclusion that the peculiar teeth of fishes and of reptiles were contrived not only as seizing and retaining instruments, but that in the opening of the mouth a necessary mechanical power was exercised by the curved teeth, which effected, in animals so constructed, the needful purpose of advancing, at every such effort, the peculiar nutriment. The animal drinks equally slowly. If the water be on a level with its body, it elevates

its head, curves its neck, and projects its long, notched tongue into the fluid, withdrawing and projecting it sluggishly for a considerable time. When satiated it seems delighted, raises its head high, waving it to and fro, performing something like smacking the lips, and accompanying the act with an audible chirp, a sound rarely heard at other times. Many were easily trained to take a drop of water from the tip of the finger.

Upon a flat surface the motions of the animal are awkward and ineffectual; among grass, on the contrary, it urges itself on sweepingly, in a sinuous course, the sides of the body and tail being the motive agents. It has a very perfect reversing action—the retrograde motion without the slightest doubt; and, in addition, it has a sort of prehensile power in its tail, by which it can suspend its body. The respiration is peculiar the animal expires at distant intervals, but no sooner is the expiration made than inspiration follows. In motion, like serpents, the animal is constantly darting out its long, partially-cleft tongue. When in vigour, as in a fine warm day, the act is like one rapid dash; but when less energetic, as in the cold of the morning, the action can be made out very distinctly to consist of three distinct waggles of the tongue up and down. I have long sought to interpret this singular act without success; but I am disposed to think it has something to do either with the search after food, or with discerning obstacles.

Skeleton.—The most notable peculiarity of the bony framework of this animal, and those of the same type, is the well-known existence of vestiges of the agents of locomotion—the rudiments of a quadruped form. In the shoulder there are most distinct scapulæ, clavicles, and a sternum; in the pelvis, besides an expansion of vertebræ, with fixed and enlarged lateral spines, there is a small bone on each side, scarcely connected with the wings of the superior sacral vertebra, which may be viewed either as a sort of completion of the circle of the pelvis, or as representing the bones of the leg.

But there are other peculiarities in the skeleton worth noting, which may not have been recorded.

In determining the co-relation of scale-plates and scales, I had at first concluded that the former were all strictly dermal. On carefully removing this bony investiture, however, plate by plate from the head, it was found that several plates, which in every other part of the body are dermal, had assumed the character of permanent bones of the head at and around the vertex. This is a condition which may probably exist in other animals of the same type. In the alligator, and its allies, something of a similar nature occurs, and in the saurians of the coal age, there is what may be pronounced a strictly identical arrangement.

In studying the skeleton of the serpent, one is constrained to view it as essentially a vertebral column, of very admirable workmanship and adaptation, surmounted by a head which, small as it is comparatively, seems principally to be occupied in giving place and development for the sentient organs, but which, besides, in the venomous tribes, is a startling array of delicate and appropriate machinery for supply and defence; in the innocuous serpents for the former purpose only, so arranged as to encompass what may be viewed as an enlarged or elongated vertebra, the brain-pan proper, forming a small portion of the head, namely, in the slow-worm, one-third in length, or 1-78th of that of the entire animal.

In the *Anguis fragilis* the bones of the head are more compact than those of serpents. It has a single row of teeth in each jaw, widely apart, on a bony setting, and so placed that, viewed from without, half the length of the basement portion is concealed by an over-lapping part of the jawbone, the pointed and curved portion only being seen above the edge of the bone; an arrangement closely analogous to that observed in the bone-clad sauroids of the carboniferous epoch.

The number of vertebræ in the whole length of the animal is 132; but if advantage be taken of a peculiar subdivision of the caudal portion, to be afterwards adverted to, the number will be considerably greater. The whole column may be arranged into 2 vertebræ in the neck, 58 in the trunk, 1 in the lumbar region, 2 in the sacrum or pelvis, and 69 in the tail.

The cervical consist of the atlas and dentata, which are very easily distinguished from each other, the atlas having two sockets, as in serpents, one which receives the ball of the occipital bone, and the other which receives the tooth of the dentata; the dentata having two balls, the tooth anteriorly, and the ball common to all the vertebræ, with the exception noted, posteriorly. The vertebræ of the body are constructed on a more simple plan than in the serpent: each has eight articular surfaces, the socket, the ball, two articular convex processes for the ribs, and four articular facets. The internal aspect is destitute of any process; the animal, accordingly, unlike serpents, has no muscular arrangement on the inner surface of the spinal column; and the processes (apart from the ribs, which are well equipped for motion), for muscular action externally, are small, all indicating a comparatively feeble action in that region. The vertebræ of the body of serpents, on the contrary, have each twelve articular surfaces, and have strong internal and external spines, with a corresponding muscular provision.

The last vertebra of the body may fairly enough be reckoned as the representative of a lumbar division; for although sometimes provided with lateral articular convexities, like the vertebræ of the body, and the short processes which represent the ribs are moveable, or one may be moveable and the other not; still, it most frequently happens that both are fixed, and, in this respect, is more like a caudal vertebra. The two sacral vertebræ have comparatively large lateral spines, and are developed appropriately for the cloacal and generative functions. The vertebræ of the tail, to a greater degree than in any of the long-tailed serpents I have examined, have a construction suited alike for quick, powerful, and varied action. Each member is furnished with six articular surfaces, and with four long spines, a superior, two lateral, and an inferior, which last is divided at its base, giving it the form of a pointed arch, in which the vessels, &c., find a secure passage.

But each caudal vertebra, with the exception of a few near the pelvis, has in itself a sort of spike-and-facet joint, the anterior third, consisting of the socket and anterior articular facets, being moveable upon the posterior and larger portion. When the extreme flexibility and strength of this part is considered, the provision thus exemplified is at once seen to be simple and adequate. So far as my observations have extended, this peculiarity of the caudal vertebræ is unique, though the same, or some modification of it, may be expected to be found in those reptiles which have a similar action of the tail.

Viscera.—The conservative and generative organs of the *Anguis fragilis*, are all but identical with those of serpents.

Diseases.—The morbid states of the animal, which I have marked, resulted probably from faults in management, in a great degree; but as numerous specimens were treated alike, and deaths were unfrequent, the causes were not distinctly traced to this source. Impaction of the rectum by a chalky matter, which appeared in every healthy dejection, to some extent, was, apparently, the cause of death in several instances. In a few instances death seemed to result from retention of numerous unvivified ova. But one specimen, which was long carefully watched, with tumours of the lower jaw, and point of the tail, furnished, on inspection, an example of positive disease. In this instance great enlargement and induration of the kidney on the left side was found to exist. Destruction of some of the vertebræ was also found; a state which might have been ascribed to pressure of the enlarged kidney, had not the external tumours been accompanied with absorption of bone of the adjacent parts. The disease, in this instance, was therefore probably malignant in character.

PROCEEDINGS OF SOCIETIES.

British Association for the Advancement of Science, Cheltenham, August 5–12, 1856.

The following detailed abstracts of the papers submitted by Professor Goodsir to Section D. at the Cheltenham Meeting of the British Association in August last, were prepared by the author for our last number :—

1. On the Morphological relations of the nervous systems in the Annulose and Vertebrate types of organization.
2. On the Morphological constitution of the skeleton of the Vertebrate Head.
3. On the Morphological constitution of Limbs.

1. *On the Morphological relations of the Nervous System in the Annulose and Vertebrate types of Organization.*

The object of this communication is to indicate the morphological character of the apparently different anatomical relations of the central portions of the Annulose and Vertebrate nervous systems.

The term Annulose is employed provisionally, and in a morphological sense, as including all animals possessing a ganglionic nervous collar and axis, and presenting, at the same time, more or less distinct indications of a segmented structure of body.

Physiologists appear generally inclined to consider the central portions of the Annulose and Vertebrate nervous systems as modified forms of the same arrangement. These forms are held to possess a general similarity of structure, and correspondence in function; and the ganglionic collar and axis of the Annulose are assumed to be homologous either with the cerebro-spinal axis, or with the series of ganglions on the posterior roots of the spinal nerves, or with the system of sympathetic ganglions of the Vertebrate animal.

In my own examination of this subject I have been strongly impressed with the necessity of determining the morphological character of the œsophageal collar, and the opposite positions of the so-called brain and abdominal ganglionic cord, before any satisfactory advance could be made in ascertaining the relations of the two forms of nervous system. The apparent morphological difference between them does not appear, in the estimation of physiologists generally, to present that obstacle to a satisfactory comparison which its essentially fundamental character would lead us to expect. The difficulty has, however, been clearly stated by Professor Owen, who, in discussing the relations of the endo- and exo-skeletons in his Lectures on Fishes, page 21, says,—" Geoffroy St Hilaire thought it needed but to reverse the position of the Crustacean—to turn what had been wrongly deemed the belly upwards—in order to demonstrate the unity of organization between the Articulate and Vertebrate animal. But the position of the brain is thereby reversed, and the alimentary canal still intervenes in the Invertebrate between the aortic trunk and the neural canal."

I must here premise, that while I hold the general morphological relations of the Annulose and Vertebrate nervous systems to be identical, I do not consider these two types of organization to be mutually reducible. On the contrary, they are fundamentally distinct, presenting differences which demand careful consideration. It is, nevertheless, incumbent on the morphologist to ascertain in what respects they correspond, so as to determine their distinctive limits.

My earlier conception of the morphology of the Annulose nervous system was based on that of Carus. I conceived that each segment of the Annulose animal contains potentially an annular nervous arrangement, set in a plane at right angles to the axis of the segment, or longitudinal axis of the animal; that the only complete nervous ring is that one through which the œsophagus passes; that the ganglions on this ring are arranged in the various forms of superior, lateral, and inferior œsophageal masses; that the nervous rings in the post-cephalic segments are all incomplete above, and have their ganglions united into a single or double mass below; and that all the rings are united by a series of longitudinal abdominal commissures. According to this view, the œsophageal collar, with its superior, lateral, and inferior ganglions, is homologous with each pair of segmental nerves, and the corresponding abdominal ganglionic centre; the œsophageal collar being in a plane parallel to those in which the post-cephalic ganglions and their pairs of nerves are situated, but at right angles to the line of the series of abdominal ganglions.

I first recognised what I believe to be the real morphological relations of the Annulose nervous system during the delivery of a course of lectures on Invertebrate Anatomy in 1849; but more fully and completely during courses on the Anatomy of the Mollusca in 1850, and on the Anatomy of the Crustacea in 1851.

I now perceived that the fundamental difference between the morphological relations of the Annulose and Vertebrate nervous systems, consists in the position of the mouth.

I saw that the entire axis or central portion of the nervous system extends along the neural aspect of the body in both types of organization; but that while, as is well known—although its morphological importance does not appear to have been perceived—the Vertebrate mouth opens into the hæmal, the Annulose mouth passes through the neural aspect of the body.

In the Annulose animal, therefore, the buccal entrance interferes with the nervous axis—passing up between the two lateral halves of one of its longitudinal commissural or inter-ganglionic cords, so as morphologically to divide the continuous axis into a *pre-stomal* and a *post-stomal* portion.

These relations are most satisfactorily seen in the Crustacea, in which the so-called brain, or supra-œsophageal ganglion or nervous mass is actually in front of the mouth, and not above it.

In Insects, Annelids, and Mollusca, the bulk of the buccal mass, and other necessary modifications of the oral apparatus, elevate the so-called brain, curving upwards the morphological axis of the body of the animal.

By comparing the indications of segments in front of the mouth, and their corresponding diverging appendages, with the arrangement and distribution of the nerves given off from the so-called brain, it appears very evident that this brain is the aggregate of the segmental nervous centres in front of the mouth.

In like manner indications afforded by the segments, and their appendages immediately behind the mouth, enable us to determine whether the so-called sub-œsophageal ganglionic mass is a single segmental ganglion, or an aggregate of antero-posteriorly united segmental ganglions.

In this way I was enabled to perceive that the axis of the nervous system of the Annulose animal does not consist of a supra-œsophageal mass, of an œsophageal collar, of a sub-œsophageal mass, and a continuous sub-intestinal ganglionic chain; but of a continuous line of connected and serially homologous ganglions situated in the mesial line of the neural aspect of the body.

The Annulose, like the Vertebrate animal, is developed with its nervous axis turned away from, and its hæmal axis applied against, the vitellary mass.*

But, in the course of development, the mouth of the Vertebrate opens through the surface applied against the vitellary mass, whilst that of the Annulose animal passes through the aspect turned away from it. The Vertebrate mouth is hæmal, the Annulose mouth neural.

Rathke formerly described the pituitary body as originating in a diverticulum passing up from the pharyngeal mucous membrane through the basis of the embryo skull. I at one time conceived it to be probable that the pituitary body, and the mucous tube, in which, according to Rathke, it originates, might be indications in the Vertebrate of a structure which, in the Annulose animal, is converted into the mouth. This presumed neural alimentary passage may be conceived as passing up between the bodies of the anterior and posterior sphenoid bones into the sella turcica, along the course of the infundibulum to the third ventricle of the brain, and through the cavity of that organ to its upper surface behind the cerebellum, thus leaving the origins of the nerves of smell and vision in the pre-stomal portion of the organ, while the origin of the nerve of hearing would remain in the medulla oblongata or post-stomal portion of the cephalic nervous mass. The arterial circle of Willis, and other peculiar arrangements at the base of the skull and brain, appeared to support the view taken. I shall not, however, pursue this hypothesis further, because, from the observations of Reichart, we know that the base of the cranium is not perforated in the embryo, and that the supposed canal or diverticulum was an incorrect interpretation of the peculiar appearances produced by the curvature downwards of the early Mammalian head.†

If I have determined aright the morphological relations of these two forms of nervous system, we shall have advanced a step in our conceptions of the anatomico-physiological relations of the Annulose and Vertebrate animals, and this without losing sight of the fundamental differences, developmental and structural, between them. The researches of Milne-Edwards, and of Newport and others, on the Annulose nervous axis may thus be physiologically associated with those of Wagner, Schroeder Van der Kolk, Owsjannikow, Jacobowitsch, and Kupffer, on the cerebro-spinal axis; and we may now legitimately employ the Annulose animal in the morphological investigation of the Vertebrate skeleton.

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* From the passage in his Lectures already quoted, Professor Owen would appear to consider the dorsal heart, with its anterior and posterior arterial trunks in the decapod Crustacean, and consequently the dorsal vessel in the Insect, Arachnidan, and Annelid, as corresponding to the thoracic, abdominal, and caudal aortic trunk of the Vertebrate animal. On this supposition only can we understand his assertion, that when the so-called belly of the Crustacean is turned upwards, its alimentary canal is still interposed between the aortic trunk and the neural canal. Embryology, Comparative Anatomy, and Physiology, appear to me, however, to afford ample proof that the cardiac-arterial dorsal trunk of the Annelid, Crustacean, Insect, or Arachnidan, is homologous not with the sub-spinal aorta of the Vertebrate, but with the primordial cardiac-arterial tube in all the forms of the embryo Vertebrate, and, consequently, with the heart and trunk of the branchial artery of the Fish. If this, then, is the real homology of the "aortic trunk" of the Crustacean, and if its "brain" is in fact only a *pre-stomal* portion of its nervous axis, the French anatomist was quite correct in his general morphological statement, although he was not legitimately entitled at the time to employ the illustration.

† I have introduced the hypothesis of a Vertebrate neural mouth (cast aside in the course of my examination of the subject), because I believe it will be found to involve relations of importance in the anatomico-physiological investigation of the pre-stomal and post-stomal portions of the Vertebrate and Annulose cephalic nervous masses.

Omitting, for the present, the consideration of the mode in which the nervous systems in the Tunicata, Rotifera, and Entozoa, are reducible to the typical Annulose form, I proceed to make some general morphological statements, based to a certain extent on the principle indicated in this, and introductory to the two following communications:—

1. The morphology of any one organic system in the Annulose or Vertebrate animal, cannot be safely or satisfactorily investigated, without constant reference to the others. That it must be so is evident from the fact, that all the organic systems are dependent on one another, in the constitution of the organism.

2. All sound morphological inquiry demands constant reference to the series of embryo, as well as of adult forms.

3. As morphology deals with forms and relations of position, it demands a careful selection of terms, and a methodized nomenclature. All terms involving more or less than their morphological application demands, must be avoided. Terms derived from other departments of the science, and having therefore an established technical meaning, have invariably produced misconception, when transferred for morphological purposes.

Influenced by these considerations, and satisfied that the Annulose and Vertebrate types of organization, although fundamentally distinct, present parallel forms of structure, and must consequently be closely linked together in morphological inquiry, I have to suggest a more extended and precise system of nomenclature for this department of the science.

In the Annulose and Vertebrate types of organization, the body of the animal consists of a linear series of segments. To the constituent segment, with its diverging appendages, I apply the term *Somatome* (σωμα. τεμνω).

For the purpose of avoiding circumlocution, and of supplying a term for a generalized conception, and thereby facilitating morphological description, without encroaching on zoological nomenclature, I denominate a segmented animal, whether Annulose or Vertebrate, an *Entomosome*—an entomosomatous animal (εντομος. σωμα).

As the constituent somatomes are invariably arranged in groups, in each of which they are more or less modified in form, or fused together, I find syssomatome (συν. σωμα. τεμνω) a convenient designation for such a group. A typical Crustacean presents a cephalic, a thoracic, and a caudal syssomatome, in each of which there are seven somatomes—twenty-one in all.

The constituent somatomes lie in planes at right angles to the *morphological axis* of the body, and are symmetrical in the transverse, but unsymmetrical in the perpendicular direction. They are, however, not only unsymmetrical in their upper and under surfaces, but the surfaces so named in the Annulose are morphologically distinct from those similarly designated in the Vertebrate animal. The Annulose animal moves on the surface which was turned away from the vitellary mass during development; the Vertebrate animal moves on the surface which was applied to it during development. As the axis of the nervous system is formed at the surface turned away from the vitellary mass, and the axis of the vascular system is formed at the surface applied to it in both types of organization, I employ, as morphological designations, the term Neuropod (νευρον.

πους) for an Annulose, and Hæmapod (αἱμα. πους) for a Vertebrate animal.

The mouth of the entomosomatous animal is invariably situated between two somatomes, and so that a certain number of somatomes are interposed between it and the anterior termination of the body. As the mouth is only one of a number of openings situated between somatomes, I find such openings conveniently distinguished as *metasomatomic*.

The mouth of the Neuropod is a neural, that of the Hæmapod a hæmal metasomatomic opening.

As the somatome exhibits in its structure corresponding segments of certain or of all the organic systems, I have found the following morphological terms extremely convenient in referring from the segment of one organic system, to the corresponding segments of the others.

For the entire framework of an Entomasome, whether this framework be developed in its integument or in its interior, whether it be fibrous, cartilaginous or osseous, I employ the term *Sclerome* (σκληρος, with the termination of completeness). To a segment of the sclerome I apply the designation *Sclerotome* (σκληρος. τεμνω). An aggregate of more or less modified sclerotomes, I name a *Syssclerotome* (συν). Making use of my former illustration, the sclerome of a typical Crustacean consists of twenty-one sclerotomes grouped in three syssclerotomes. Again, the sclerome of a Mammal consists of a number of sclerotomes, grouped into the cephalic, cervical, thoracic, lumbar, sacral, and caudal syssclerotomes.

For the muscular system I employ the terms *Myome*, *Myotome*, *Synmyotome*; for the nervous system, *Neurome*, *Neurotome*, *Synneurotome*; for the vascular system, *Hæmome*, *Hæmatome*, *Synæmatome*; for the morphologically as well as physiologically important digestive system, with its segments, and groups of segments, *Peptome*, *Peptatome*, and *Synpeptatome*, &c.

Till very lately, I had not met with any indication of the actual morphological character of the so-called supra-œsophageal ganglion in the works of British or Foreign Physiologists. I have now found, in an obscure corner of Von Baer's works, sufficient evidence that he had recognized its pre-stomal character. His statements are contained in a single paragraph, which forms an episode in the middle of the second corollary of the fifth scholium of his work on the Development of the Chick *in ovo*. Von Baer holds, with E. H. Weber and Treviranus, that the nervous axis of the Neuropod is homologous with the series of ganglions on the posterior roots of the spinal nerves of the Hæmapod; and he considers the "supra-œsophageal" ganglion to be the homologue of the Gasserian ganglion; but he adds, "peculiar stress is laid on this, that it (the supra-œsophageal ganglion) lies above the mouth (über). This appears to me to be a false view of the matter; it lies, in fact, in front of (vor) the mouth." He gives a diagram of the arrangement, and proceeds: "The following sketch will make it evident that the so-called brain of the Insect has the same signification as the posterior ganglions; and the œsophageal ring is only a secondary formation, dependent on the breaking through of the mouth, permitted by the symmetry of the structure, and the necessary connection of the ganglions."

It is somewhat remarkable that no one, even of Von Baer's own countrymen, has, so far as I know, made any allusion to this passage. Indeed, he does not appear to have been himself aware of the value of the observation, as he adduces it merely in the form of an argument in illustration of another subject, and does not again recur to it. For my own part, having ascertained, on independent grounds, and publicly taught and illustrated, for some years the principle stated in this communication, I feel gratified in having this opportunity of rescuing from temporary oblivion, and of adducing in support of my own statement of the principle the original announcement of it, made twenty-eight years ago, by one of the most philosophic of modern Anatomists.*

2. *On the Morphological Constitution of the Skeleton of the Vertebrate Head.*

In an abstract which professes to give only the general results of my own investigations, I cannot enter into such critico-historical details as would be necessary were the corresponding or opposite results obtained by other inquirers to be in every instance brought forward. I am therefore obliged at present to state, in a somewhat dogmatic form, the results which I conceive I have obtained, and the views I have been induced to take of a subject in itself extensive and difficult, and one to which so many distinguished anatomists have devoted themselves.

Nature of the subject.—The framework of the Vertebrate head is a sysclerotome—that is, a group of sclerotomes variously modified, and more or less connected, so as to form a distinct whole. The points to be determined are the number and modifications of the sclerotomes in the various forms of Vertebrate head. There are, however, some preliminary questions which must be briefly examined.

The source and mode of origin of the Sclerome in the Vertebrate Embryo.—The knowledge we at present possess of the source and mode of origin of the Vertebrate sclerome is the result of the successive researches more particularly of Pander, Von Baer, Rathke, Reichart, and Remak, on the development of the blastoderma.

Von Baer, while he adopted the doctrine of Pander regarding the so-called "serous" and "mucous layers," took a somewhat modified view of the "vascular layer," and directed attention more particularly to the "dorsal" and "ventral folds" of the blastoderma, in connection with the "corda dorsalis," as fundamental embryological characteristics of the Vertebrate type of organization.

Among the numerous results of the researches made by Rathke in every department of Embryology, there are two which bear particularly on the present subject. These are his early discovery of the so-called branchial clefts; and his later recognition of the fact that the series of quadrilateral bodies on each side of the "corda dorsalis," instead of being the rudiments of vertebræ, contain potentially the germs not only of these bones, but of the dorsal muscles, and "probably" of spinal nerves.

Reichart supplemented the previous observations of Rathke on the development of the "branchial" or "visceral laminæ," and of the nasal and maxillary portions of the face.

Finally, Remak has ascertained, on independent grounds, that each pair of the dorsal quadrilateral bodies, usually considered as the rudiments of vertebræ, becomes developed superiorly into a right and left muscular plate, and inferiorly into a pair of spinal nerves, with their ganglions, along with the rudiments of a vertebra and pair of ribs, the nerves being in front of the sclerous elements. In the course of development a change takes place in this "primordial vertebral system." The rudiments of the vertebral arch and ribs move backwards, from their original site under the posterior margins of the overlying muscular plates, to the anterior margins of the pair of muscular plates immediately behind, and become united to both pairs. A transverse division takes place at the same time in the rudimentary central masses of each of the primordial vertebræ. These changes constitute a new order of parts—the order or arrangement of the "permanent vertebral system." Thus, the products of the development of a single primordial vertebra are—1. A pair of spinal nerves, with their ganglions; 2. The vertebral arch and pair of ribs immediately behind this pair of nerves; 3. The anterior part of the body of the vertebra to which this arch and ribs are attached; 4. The intervertebral disk in front of it; 5. The posterior part of the body of the vertebra in front; and, 6. The group of spinal muscles between these two vertebræ. The bones, muscles, and nerves of the abdominal and thoracic wall are formed by an extension downwards, and adhesion of the lower or costal portion of the "primordial vertebral system" to the inner surface of the external of the two layers into which the "primary abdominal wall" divides. This outer or adherent layer of the "primary abdominal wall" becomes the areolar layer of the integument, and enters into the formation of the limbs. The inner layer, separated from the outer by the pleuro-peritoneal space, forms, with its fellow of the opposite side, the Wolffian bodies, reproductive glands, spleen, permanent aorta, mesentery, and the muscular and serous covering of the alimentary tube.

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* I accidentally discovered, a few weeks ago, that Professor Huxley had published translations of portions of Von Baer's works in the Scientific Memoirs for 1853. This judicious selection contains the passage referred to in my paper. (Dec. 4, 1856.)

From these remarkable observations of Remak, it would appear that the sclerome of the Hæmapod, from the anterior part of the neck backwards, originates as a series of independent sclerotomes, and that, contemporaneously with each sclerotome, a corresponding myotome and neurotome take their rise in a common primordial segment of blastema.

The cephalic portion of the early Vertebrate embryo is peculiar, more particularly, according to Remak, in the nonappearance of distinct "primordial vertebræ," and of the subsequent changes which result from their development. The great divisions of the brain and of the cerebral nerves indicate, indeed, the segmented character of the entire structure, but I am inclined to believe that, in the present state of the subject, these indications are not to be depended on for the determination of the segments of the embryo or adult head. It appears to me that the segmented structure of the brain is to be looked for, not in its greater masses,—those developments on its upper surface in which it differs from the spinal cord, and by the possession of which it becomes a brain,—but in the series of groups of ganglion cells, the nervous centres of the cerebral nerves, whatever the typical number of these may be, arranged along its base, and strictly homologous with the groups of ganglion cells which undoubtedly constitute the morphological segments of the spinal cord.

The "visceral," or "branchial laminæ" afford, in the present state of the subject, a more secure embryological basis for the determination of the segments of the head. The so-called "first visceral lamina," the one in which the mandibular arch is developed, and the two succeeding "visceral laminæ," those in which the anterior and posterior segments of the hyoid of Mammals and Birds are formed, must be looked upon as embryological indications of three cephalic segments.

On the under surface of the forepart of the embryo head, in front of the so-called "first visceral lamina," there are five processes, in which are developed the palate and pterygoid, the maxillary, malar, and lachrymal, the intermaxillary and nasal bones. The first of these processes on each side extends obliquely forwards from the "first visceral lamina" towards and under the eye. It is the so-called "superior maxillary lobe." The second process on each side—the "lateral frontal process" of Reichart—passes down in front of the eye, the eye being situated in the cleft between it and the former process. The fifth process is situated in front, and in the median line. It is the "anterior frontal process" of Reichart. The clefts or notches between this process and the "lateral frontal process" are considered by Rathke and Reichart to be the external nostrils.

Now, in regard to the so-called "superior maxillary lobes," it is clearly established that the palate and pterygoid Bones are formed in them, but there is no sufficient evidence that they contain the germs of the superior maxillary bones. No traces of the superior maxillary bones appear until these so-called "superior maxillary lobes" have extended forwards, and united with the "lateral frontal processes" and the "nasal process," and until the maxillary margin has become considerably extended. I am, therefore, of opinion that the "lateral frontal processes" of Reichart are, in fact, the real maxillary lobes, and contain not only the germs of the lachrymal, but those also of the maxillary and malar bones. This view of the place of origin of the superior maxillary is in accordance with the adult relations of these bones. The position of the superior maxillary is in front of the eye; the orbit being, in fact, an expanded cleft between it and the palate bone.

Again, the nasal bones of the Mammal are formed in the upper part, and the intermaxillary bones in the lateral angles and palatal lobes of the "anterior frontal process." The notch or cleft on each side of this process cannot therefore become the external nostrils, for these are not situated in the Mammal behind the intermaxillary bones, but in front of them. From these circumstances, I am inclined to consider the external nostrils of the Mammal to be formed by the transverse union of the palatal lobes of the "anterior frontal process;" and by the formation of the cartilages of the external nose in the mesial portion of the free margin of that process.

Embryologists generally consider the so-called superior maxillary lobes to be the upper portions of the "first visceral lamina" bent forward, and the "lateral" and "anterior frontal processes" to be the superadded structures in no way related to the "visceral" or "branchial laminæ." It appears to me, however, that the general aspect, the relations, and the changes undergone by them in development prove these parts to be serially homologous with the "visceral laminæ," and to be, like them, indications of the segmented structure of the head in front of the so-called first visceral arch. The so-called superior maxillary lobes indicate a segment of which the palate and pterygoid bones are elements. The "lateral frontal" indicate a second segment containing the maxillary, malar, and lachrymal bones. The external margins and angles of the "anterior or frontal processes" indicate an intermaxillary segment; and the development of the mesial part of the same process into the cartilages of the nose indicates a segment probably only fully developed in the Mammalian head.

In addition, therefore, to the "visceral laminæ" behind that one in which the mandibular arch is formed, there would appear to be a series of less developed "visceral laminæ" in front of it, all of which, in addition to other structures, give rise to hæmal arches of the sclerome, and indicate a number of corresponding sclerotomes.

Of the Primary or Fibrous Sclerome.—The bones and cartilages to which, from their palpable character, the attention of anatomists has been hitherto chiefly directed, are parts only of the Vertebrate sclerome. They are imbedded in a continuous fibrous matrix which, variously modified, binds them together, and co-operates in their general economy and functions. This matrix forms a more extensive, and, in some respects, a more important element of the sclerome in the lower than in the higher Vertebrata; and if viewed in the former in connection with

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its early stages of development in the embryo, it will be found to be arranged on the plan of the "primordial vertebral system." It is most satisfactorily studied in the Fish, and particularly in those forms in which the bones and cartilages are feebly developed. The fibrous element of the sclerome forms the sheath of "corda dorsalis" in the Lancelet, and envelopes the column formed by the bodies of the vertebræ in other Fishes. It then bounds the neural and hæmal cavities, and from these cavities passes in the mesial plane above and below to the neural and hæmal margins of the body. Corresponding cartilaginous and osseous parts are imbedded in these fibrous neural and hæmal laminæ. From the right and left sides of this deep or central system of fibrous laminæ, other laminæ extend outwards between the myotomes and are connected to the deep fibrous layer of the integument. The bones usually distinguished as "additional ribs," "upper ribs," "epipleural spines," "diverging appendages," are imbedded in these metamyotomic laminæ; and as the class of radiating bones to which these so-called additional ribs belong may be conveniently distinguished as actinapophyses (*ακτισ-ινοσ*), I apply the term actinal to the metamyotomic fibrous laminæ of the sclerome. As those dermal bones or plates which, from their histological as well as their teleological characters, certainly constitute elements of the sclerome, are formed in the layer of the integument to which the actinal sclerous laminæ are attached, this integumentary fibrous structure must be considered as constituting a dermal sclerous lamina, and so completing the fibrous portion of the sclerome.

The sclerome thus consists fundamentally of a fibrous structure, which surrounds the "corda dorsalis," bounds the neural and hæmal cavities, forms a mesial septum above and below, separates the myotomes from one another, and, under the integument, envelopes the deeper parts.

The Development of Cartilaginous and Bony Elements in the Fibrous Sclerome.—The immediate development of certain bones from or in a fibrous matrix, and of others in cartilage previously formed in it, has given rise, among other questions, to one, as to whether the former are to be included in the vertebrate system of bones. Now, while I admit the importance of the embryological and histological facts which the discussion of this question has afforded, I am inclined to think that a histological bias has influenced both the views which have been taken of it. Why certain bones originate in a fibrous matrix, why others originate in cartilage which has been previously formed in the same matrix, are questions of undoubted importance, but which at the same time cannot legitimately be put in opposition to the unity of the fully developed sclerome.

Of the Cartilaginous and Bony Elements, and of the general Morphological Constitution of the Sclerotome.—A sclerotome is, fundamentally, a segment of the fibrous sclerome, and the series of fibrous sclerotomes is indicated by the actinal laminæ, each of which, for reasons to be afterwards stated, ought probably to be considered as potentially double, that is, as consisting of two layers, one belonging to the sclerotome behind, the other to the sclerotome in front.

The fully developed Hæmapod sclerotome is therefore a fibrous structure, in which all the cartilaginous and osseous parts are formed and embedded. With regard to these cartilaginous or osseous elements, I shall at present only direct attention to certain points which bear on the constitution of the sclerotomes of the Head. In doing so, I must bear testimony to the general applicability and convenience of the terms employed by Professor Owen to designate the elements of his typical vertebra, venturing to suggest modifications in their application only where I am compelled to differ from him in regard to the relations of the elements themselves.

The term "centrum" is highly useful as a designation for the cartilaginous or osseous mass formed around the "corda dorsalis," whatever the constitution of that mass may be.

The neurapophyses or hard parts developed in the lateral neural laminæ are "typically" two at least on each side. Not only are there two on each side in the trunk sclerotomes of certain cartilaginous and probably osseous Fishes; but there are two on each side in certain cephalic sclerotomes in at least Fishes and Reptiles. Professor Owen admits one neurapophysis only on each side of his typical vertebra. He accounts for the additional pair in the spine of the sturgeon on the principle of "vegetative repetition;" while the additional elements in the neural arches of certain cephalic vertebræ he at one time considered as parapophyseal, and latterly as diapophyseal elements. But it appears to me that a principle of "vegetative repetition" is out of place in a morphological question; and a parapophysis cannot, according to Professor Owen's archetype, be intercalated between a neurapophysis and a neural spine; nor can a diapophysis become an independent element.

The superior or posterior spinous process, "neural spine," or (as a more convenient general designation) metaneurapophysis, is developed in the mesial neural fibrous lamina. As this element is situated in the mesial plane, it is potentially double, and its right and left halves become depressed and more or less flattened out in the cephalic sclerotomes. With the neurapophysis it completes the neural arch.

The cartilaginous or osseous elements developed in the lateral and mesial hæmal laminæ of the fibrous sclerotome constitute the hæmal arch. The fundamental character of the inferior or hæmal arch, as I understand it, consists in this that its constituent elements take their rise at or close to the inner surface of those "ventral laminæ" or "folds" in the embryo, which form the lateral and inferior walls of the visceral chamber. Every hæmal arch, therefore, within the antero-posterior range of the alimentary tube must, according as it is more or less developed, necessarily inclose that tube more or less completely. Accordingly no arch within the range of that tube, if it excludes the tube, can be considered as a hæmal arch, merely because it incloses great bloodvessels. Again, before any arch beyond the range of the alimentary tube can be considered as a proper hæmal arch, its development must have been ascertained; or its relations to those muscular, vascular, but more particularly nervous elements, which constitute in their respective systems the arrangements corresponding to the hæmal arch in the sclerotome, must have been determined.

I must confess therefore my inability to discover the precise view of the hæmal arch taken by Professor Owen. Judging from his diagram of the "ideal typical vertebra," and from his general treatment of the subject, a chevron bone in the Reptile or Mammal, or that portion of the cervical vertebra in certain Birds which completes the canal beneath the centrum, represents the primary typical form of this arch. It would also appear to follow from his doctrine, that the expanded form of hæmal arch, provided for the lodgment of the central organ of circulation, and presented by the thoracic segments, is a secondary formation—the result of the removal of the primary hæmal arch from its "typical" position under the centrum, and its intercalation between the elongated pleurapophyses. But this doctrine appears to me to involve embryological contradictions. The relations of these primary and secondary forms of hæmal arch in the neck and throat respectively are not explained by it. The so-called hæmal arch under the cervical vertebra of the pelican is undoubtedly hæmal in function; but as it excludes the œsophagus and trachea, it cannot be the real or morphological hæmal arch. In other words, this so-called hæmal arch cannot have been formed in the "visceral laminæ" of the embryo neck.

Again, it is difficult to conceive how the pleurapophyses and hæmal arch of Professor Owen's "ideal typical vertebra" can be developed together in the "ventral folds" of the embryo. For, according to the doctrine of Professor Owen, a pleurapophysis may, in different instances, present two sets of relations. In the thorax it is attached by opposite ends to adjoining sclerous elements, and lies in the wall of the hæmal chamber. In the neck and tail it is connected to its own vertebra at one end only, and does not lie in the wall of the hæmal chamber. The mode in which the continuously arranged elements of the costal arch of a Bird—the "pleurapophyses," "hæmapophyses," and "hæmal spine"—are developed in the embryo is known. But it is difficult to conceive how the detached and peculiarly arranged "pleurapophyses" and "hæmal arch" as represented in the "ideal typical vertebra," or exemplified in a proximal caudal vertebra of a Reptile or perenni-branchiate Amphibian, have assumed the positions they occupy, if they belong to the same group of elements—that is, if they all spring from or originate in the wall of the visceral chamber.

Is the pleurapophysis a fundamental or primary element of the hæmal arch? In other words, is it originally developed in the wall of the visceral cavity, and in certain instances afterwards extruded from it? or is it merely a secondary element in the hæmal arch, that is, formed externally to, or away from it, and only intercalated into it in certain vertebræ?

As a rib, so far as its development has been traced in the series, appears to be formed in the inner layer of the "visceral lamina;" and as it is previously connected or continuous with the diapophyseal portion of the neurapophyses, its head and neck being secondary formations, I am inclined to consider the caudal transverse processes in the Mammal, Lizard, and Amphibian, as lying in the position of the original "ventral folds;" and that, therefore, the feebly developed "pleurapophyses" of this region are the only representatives of its hæmal arches; while the chevron bones have no title to this morphological distinction.*

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* In dissecting lately a large crocodile, I found that an aponeurotic membrane extended outwards and curved downwards on each side from the extremities of the caudal transverse processes. These aponeuroses met one another in the mesial line below the tail and were there joined by a mesial aponeurosis which extended down from between the chevron bones. A layer of fat one-third of an inch in thickness lay on the outside of the lateral aponeuroses; and embedded in it the hæmal divisions of the spinal nerves extended outwards, downwards, and backwards, like a series of intercostal nerves. The lateral muscular mass of the tail arranged in myotomes with meta-myotomic fibrous laminæ, nearly as distinct as in the fish, lay on the outside of the layer of fat. Each of the lateral aponeurotic cavities was occupied by the "fémoro-péronéo-coccygien" muscle of Cuvier, which arose from the under surfaces of the transverse processes, the sides of the chevron bones and mesial aponeurosis, and passed out of the cavity through a space left in its outer wall behind the ischium to be inserted into the thigh bone. The mesial membrane divided above; its two laminæ corresponding to the limbs of the chevron bones, and passing in front into the walls of the pelvis.

This arrangement appeared to me to indicate that the transverse processes, the lateral aponeuroses, and the hæmal divisions of the spinal nerves, were in the position of the proper hæmal arches of the tail; that the two aponeurotic chambers constituted in fact, together, the abdominal or visceral cavity, divided by the mesial lamina, and occupied by a pair of muscles, referable to that group of muscles which in the trunk lie on the inner surface of the visceral chamber; and that therefore the chevron bones are not real hæmal arches, but subcentral developments.

The processes which complete the canal under the posterior cranial and anterior trunk centrums in certain Fishes, and of the cervical centrums in certain Birds, are probably of the same nature as the chevron bones, which, according to Joh. Müller, appear to be developments of the inferior pair of constituent pieces of the centrum.

We are entitled, then, to require that every part to which the pleurapophyseal or hæmapophyseal character is attributed, should have been proved by direct observation, or otherwise, to have been developed in the "ventral folds."

It appears to me very doubtful whether there are sufficient grounds for limiting the number of morphological elements in the hæmal arch to one pair of "hæmapophyses" and a "hæmal spine;" or to a pair of "pleurapophyses," a pair of "hæmapophyses," and a "hæmal spine;" while an increase in the number of sclerous pieces is accounted for by the principle of "vegetative repetition," or "teleologically." While I admit the grouping of the elements of the more complex hæmal arches into an upper and a lower series, I am compelled on philosophical grounds to deny that the subdivision of a "pleurapophysis" or of a "hæmapophysis," is beyond the range of morphological law; or that morphology and teleology are distinct in the sense that the latter principle provides for what the former is insufficient. Morphology and teleology are merely opposite, because, in the at present phase of science, necessary anthropomorphic aspects of the same Divine principle evinced in the laws of organization.

Until then we know more than we do at present of the laws which regulate the number of "centres of chondrification and ossification;" and, until the constitution of the inferior vertebral arches in the embryo and adult series has been more fully analysed, I cannot give my assent to the expression for a hæmal arch involved in Professor Owen's osteological doctrine.

I must here allude to a point which does not appear to have attracted that attention which it deserves. None of the hæmal arches of the head inclose the hæmal axis. If we are to consider the so-called median and lateral frontal with the superior maxillary lobes as visceral laminæ, then, as such, they have no primordial relation with the hæmal axis, which, under the form of the cardiac-branchial tube, extends forward as far only as the so-called "first visceral lamina." After the hæmal arches have been formed in "the first and other visceral laminæ," usually so called, of the head, the hæmal axis is found to be excluded from them. It is in consequence of this remarkable developmental arrangement, that the heart, branchial artery, and its branches, in the Fish and Amphibia, are situated below and external to the skeleton of the branchial apparatus.

Before pointing out what appear to me to constitute certain of the developmental conditions on which this peculiar relation of the hæmal arches of the head to the hæmal axis is dependent, I must direct attention to another relation, in which the cephalic hæmal arches are peculiar. The hæmal arches of the head are in immediate contact with the alimentary tube; they are lined by the mucous membrane, which is also in contact with their centrums. There is, in fact, no extension of the peritoneo-pleuro-pericardiac space into the head. The cephalic portion of the primary abdominal wall (Kopfseitenplatte of Remak) becomes from the first united to the corresponding portion of the cephalic primordial vertebral system (Kopfurwirbelplatte); and the former, instead of dividing into two layers, one for the wall of the alimentary tube, and another for the wall of the visceral cavity, with a serous space between them as in the trunk, becomes, in conjunction with the latter, perforated by the branchial clefts.

The hæmal portion of the head, therefore, is distinguished from the corresponding portion of the trunk, in presenting meta-somatomic clefts, in having no serous cavity, and in having the hæmal axis external to the hæmal arches of its sclerotomes. We are not yet in possession of sufficient data to explain these various peculiarities of the head in the Hæmapod. I must direct attention, however, to the following facts, which bear upon the cephalic exclusion of the hæmal axis. The anterior portion of the primordial alimentary tube, from the cul-de-sac in which it terminates in front, back to its vitellary margin, consists essentially of two parts; a cephalic portion, terminated by the cul-de-sac, is bounded laterally by the "visceral laminæ," from the so-called first pair of laminæ backwards, and becomes developed into the pharynx; and a cervico-thoraco-abdominal portion, bounded laterally by the anterior portion of the primordial vertebral system of the trunk and the corresponding portions of the primary ventral wall. The primordial hæmal axis (heart and branchial artery) is formed within the pericardiac space, on the inferior aspect of the posterior or trunk portion of the tube from which are afterwards developed the œsophagus, stomach, duodenum, liver, pancreas, and lungs. The heart and pericardium are at first comparatively large, project downwards, and only pass backwards at a comparatively late period into the interior of the hæmal arches of the thoracic sclerotomes in Reptiles, Birds, and Mammals. The cephalic portion, or pharyngeal cul-de-sac, on the other hand, does not present originally any traces of the development of the hæmome. This may be to a certain extent explained by the great comparative development of the cephalic portion of what would have been formerly considered the "serous layer" of the blastoderma. The extremities of the so-called "first visceral laminæ" have in fact approached one another below, before the apex of the cardiac tube has advanced so far forwards as to communicate with them. The precise conditions, however, which determine the formation of the sclerous elements of the mandibular, hyoidean and branchial arches on the inside of the corresponding vascular arches, remain to be ascertained by future inquiry. At present I can only conceive of these conditions as in some way dependent upon the developmental relations to which I have alluded.

These relations of the hæmal arches of the head must be taken into consideration in determining the signification of the branchial arches of the Amphibian and Fish. The division of the sclerous system, into dermo, neuro, and splanchno skeleton was first systematically carried out by Carus. I was early brought, by the study of the works of the philosophical and ingenious Dresden Anatomist, to adopt this three-fold division of the skeleton. I have latterly, however, been induced to reject as untenable the doctrine of a splanchno-skeleton. I believe it may be confidently asserted that no structure referable in any way to the skeleton is developed in or around any portion of the mucous layer of the vertebrate alimentary tube beyond that part of it which belongs to the head; in other words, beyond the pharynx, or part perforated by the branchial clefts. The mandibular, hyoidean, branchial, and pharyngeal arches, the cartilages of the larynx, trachea, bronchial tubes, and lungs, are all primarily developed in immediate relation to the cephalic portion of the alimentary tube.

It is remarkable that those who refer the branchial and pharyngeal arches to a splanchno-skeleton, have not adduced the external position of the hæmal axis to these arches as an argument in support of their opinion. On this ground, however, the hyoidean, and, I believe, the mandibular arch also, as internal to the first, or to the first and second aortic arches, would be also thrown into the system of the splanchno-skeleton. Carus has accordingly done so in the case of the hyoidean arch; but Professor Owen, overlooking the fundamental embryological relations which indissolubly connect all these arches as serially homologous, holds the hyoidean to be a "strong, bony, persistent arch of the true endo-skeleton;" while, on grounds which appear to me altogether secondary, he refers the branchial and pharyngeal to the splanchno-skeleton, and thus relieves himself of the onus of determining their "homologies." From the view I have been led to take of this subject, I am under the necessity of considering these arches as true hæmal arches, and as certainly referable to the endo-skeleton as the mandibular arch itself. I also, for the same reason, conceive that the complete morphology of the skeleton of the head includes the homologies of the cartilages of the larynx, trachea, and lungs.

The cartilages and bones developed in the actinal fibrous laminæ are most important elements in the sclerome. In the head they are variously modified and arranged, not only for the protection of organs, but also as a system of props to afford additional security to the fundamental parts of the skeleton. In the trunk they are chiefly subservient to the myome. They thus exhibit their highest development in the framework of the limbs, for the entire constitution of which they alone, I believe, supply the elements.

The bony rays developed in the meta-myotomic laminæ of Fishes exhibit the most elementary forms of actinapophyses. Here, again, I must differ from Professor Owen, who limits the number of these "diverging appendages" to one—generally attached to the pleurapophysis—on each side of the vertebra. This "epipleural element" he considers to be a part of the endo-skeleton, while the additional radiating bony filaments he refers to the exo-skeleton, and recognises in them a manifestation of the principle of "vegetative repetition." While I admit that the so-called "epipleural spines" are the most constant of these bones, yet as the others are developed in the same fibrous membrane, which has, moreover, no primary relation to the dermal system, I cannot see on what grounds they can be excluded from the endo-skeleton. As, again, I cannot avail myself of the principle of "vegetative repetition" in a morphological inquiry, and as I find all of these "additional ribs" connected with important modifications of the myome, I account for their presence teleologically, and hold, therefore, that they must also be explicable morphologically.

The question as to the typical number of actinapophyses in a sclerotome cannot, it appears to me, be determined in the present state of the science. Their existence and general morphological relations having been ascertained, the conditions which determine their position and number must remain for future inquiry.

On these grounds I cannot, with Professor Owen, regard the branchiostegal rays on each side collectively as a single "diverging appendage." I not only recognise on each side of the hyoidean arch of the osseous fish one series, but a double series of actinapophyses. This double arrangement of the branchiostegal rays has not, so far as I know, been recorded. One series of these rays are attached along the outer, and therefore morphologically anterior surface, and the other along the inner, and therefore posterior surface of the cerato-hyal; but as the two series are attached, the one to the upper, the other to the lower part of the bone, they form together a single range for the support of the branchiostegal fold.

I recognise a similar but more developed form of this double arrangement of actinapophyses in the variously modified cartilaginous or semi-osseous double styles or plates which are attached to the convexities of the branchial arches for the support of the respiratory membrane of osseous Fishes. These branchial actinapophyses also exhibit that jointed or multiarticulate structure so generally presented by the rays of the mesial and bilateral fins.

This leads me to observe, that I have not been able to satisfy myself of the truth of the doctrine at present generally held, that the inter-spinous bones and rays of the mesial fins belong to the dermo-skeleton. I admit that, in certain instances, these fins present more or less dermal bone in their composition; but I cannot see how fin-rays, from which the skin and sub-cutaneous texture may be stripped, can be considered as portions of the dermo-skeleton. These rays can scarcely, I conceive, be referred to the dermo-skeleton in the cartilaginous Fishes; and as the rays of the bilateral fins resemble those of the mesial in their histological as well as in their general relations, they ought to be placed in the same category. The rays of the mesial, as well as of the bilateral fins cannot, therefore, in my opinion, be consistently excluded from that portion of the sclerome usually denominated neuro- or endo-skeleton; but like other elements of the endo-skeleton which approach the dermal sclerous fibrous lamina, they may coalesce with dermal bone.

I have been led to consider the inter-spinous bones and mesial fin-rays as actinapophyseal elements. With reference to the mesial position and characters of these bones, I would remark, that it appears to me to be quite permissible, on morphological grounds, to look upon each inter-spinous bone, with its corresponding fin-ray, as consisting of a right and left actinapophysis mesially united,—that is, to consider the right and left halves of which they consist in the young fish as fundamental elements of opposite sides of the body. This view of the actinapophyseal character of the bones of the mesial fins appears to be supported by the occurrence of double anal and caudal fins in monstrous fishes, and also by the so-called urohyal bone. The relations of this bone appear to me to indicate that it is not referable to the basohyal elements of the arch, but to the actinapophyseal. I recognise it as consisting of two of these elements fused together at the mesial plane.

I am further supported in the view which I take of the actinapophyseal character of the inter-spinous bones and mesial fin-rays, by the well-known and hitherto unexplained antero-posterior duplicity which they exhibit in certain fishes. In the Pleuronectidæ, for instance, the inter-spinous bones are attached in pairs, one bone in front and another behind each spinous process. In these instances I conceive we have examples of mesial anterior and posterior actinapophyses in each sclerotome. The corresponding fin-rays are, it is true, alternate, but this does not affect the general principle, when we keep in view the remarkable antero-posterior movements of certain elements of the sclerome discovered by Remak in the embryo, and the highly important observations of Professor Owen with reference to the alternations of some of the elements of the spine in certain Reptiles and Birds,—alternations undoubtedly referable to movements of the kind discovered by Remak.

In the head actinapophyseal elements are generally bar-like, or more or less flattened from without inwards. From the peculiar forms assumed by these elements in the head, an anterior actinopophysis of one sclerotome may meet a posterior one from the sclerotome in front, so as to form together a bar-like or flattened bridge, or buttress, between the two. These bridge-like connections of neighbouring sclerotomes are not unfrequently completed by the fibrous basis of the sclerome. In Birds, and the typical Lacertians, indeed, in which the actinapophyseal elements exhibit remarkable adaptations, the fibrous matrix in which they are imbedded, and by which they are connected, forms an essential feature of their arrangement.

The actinapophyseal elements of a sclerotome are to be distinguished as hæmal and neural—those attached to the hæmal and those connected with the neural arches. The hæmactinapophyses are the most usual and numerous, and have hitherto been alone recognised as such by anatomists. I shall therefore at present only remark, in reference to the neuractinapophyses, that I consider as such the neural range of "additional ribs," the interspinous bones and rays of the dorsal fins, and of the neural half of the caudal fin in cartilaginous fishes, and also the interneural cartilages, to which attention was first directed by Joh. Müller. In the cephalic sclerotomes, the neuractinapophyses constitute the so-called "sense capsules" and the system of "muco-dermal bones." The so-called "muco-dermal bones" have been latterly referred by the continental anatomists to the dermo-skeleton. I am, nevertheless, inclined to believe, that when the general morphological relations of these bones, and their existence in at least Reptiles and Birds, are taken into consideration, they will be admitted as elements of the endo-skeleton. They are not the only bones in the head of the osseous Fish which are traversed by mucous tubes; but from their superficial position they generally are so, and from the same circumstance are frequently overlaid by dermal bone. Professor Owen has adopted the doctrine of the muco-dermal character of these bones, and includes the lachrymal among them. Believing the lachrymal to be a cephalic neuractinapophysis, I cannot assent to the rejection of this bone from the endo-skeleton, and more particularly to referring the perforation which generally characterises it to the system of dermal mucous canals. The lachrymal canal is a metasomatomic opening. It is the remaining portion of the cleft between the maxillary and palatine visceral laminæ. The lachrymal bone is situated at the upper end of this cleft, at the extremity of that metasomatomic space in which the eyeball is situated—viz., the orbit. The lachrymal bone is therefore grooved or perforated by an integumentary canal which, as a portion of one of the original clefts in the wall of the face, is retained in the adult as a passage for the secretion of the lachrymal gland.

The most important cephalic neuractinapophyses are those fibrous, cartilaginous, or osseous structures which support and protect the nose, eye, and ear. They exhibit their fundamental character most distinctly in the Cyclostomatous and Plagiostomatous Fishes, in which they consist of sessile or pedunculated cartilaginous cups or capsules attached to the outer margins of the cranium. In the other Vertebrata these "sense capsules," variously modified in form and texture, become more or less involved in the wall of the cranium. In their fundamental form they must be considered as parts of the endo-skeleton, homologous in the Hæmapod with those parts of the dermo-skeleton of certain Neuropods, such as the Crustacean, which carry the organs of sense, and are serially homologous with its masticatory and ambulatory limbs.

Professor Owen refers the "sense capsules" to the splanchno-skeleton. But the organs of hearing, vision, and smell, are developed not from or in connection with the mucous layer of the blastoderma, but from the so-called "serous layer"—that is, from that superficial layer which produces the skin, its appendages, the cerebro-spinal axis, and the primordial vertebral system. It appears to me that it would have been more natural to refer the sense capsules, as De Blainville did, to the dermal system; but their histological, embryological, and general relations, indicate, I believe, their real nature as parts of the neuroskeleton.

The most complex and important development of the actinapophyseal elements of the sclerome are those arrangements which constitute the framework of the limbs. As, however, I find myself compelled to dissent from Professor Owen's determination of the anterior pair of limbs as the hæmal arch and "divergent appendages" of the occipital vertebra; and as I also dissent from his general doctrine of limbs, I shall reserve my observations on the subject for a separate communication.

The osseous formations in connection with the subintegumentary fibrous lamina constitute collectively the dermal portion of the sclerome. As the constitution of the exo-skeleton does not immediately bear on the object I have in view, I shall merely observe, in reference to it, that a more extended and systematic investigation of its structure and morphology is at present very much to be desired.

From the statements already made, it will be observed that I consider that the most general conception we can at present reach of a vertebra or sclerotome, is a somewhat expanded or detailed form of Von Baer's ideal transverse section of the Vertebrate Animal, which is based on the original neural and hæmal foldings of the blastoderma from the sides of the corda dorsalis. With reference to the further development of the idea, I venture to express my decided opinion, that formally to announce the archetypal number of elements in a segment of the skeleton is a premature attempt at generalisation, and that a dogmatic statement on a subject of this kind must have a greater tendency to check legitimate induction the higher the authority from which it emanates.

The modifications which occur in the Sclerotomes towards or at the front of the Head.—It is generally admitted, that in tracing backwards the series of sclerotomes in a vertebrate animal, they become modified in form in proportion to the withdrawal of the other organic systems, until at last the sclerotome may become a mere nodule or filament. Although it is also generally admitted that a certain amount of deterioration takes place in the sclerotome towards the anterior part of the cranium, the nature and extent of the change has not hitherto been precisely determined. I find that it presents, according as the nasal fossæ are or are not present, two forms.

First general form of deterioration.—The deterioration is much less in the first form than in the second. The first form may be best observed in the Mammal, in which alone the nasal cavities are complete. The nasal fossæ of the Mammal are bounded below by a series of at least four hæmal arches, the palatine, maxillary, intermaxillary, and ali-nasal, which, along with the soft parts, form collectively the palatal vault of the mouth, with the upper lip and under surface of the external nose; these three continuous surfaces forming in fact the anterior part of the sternal or hæmal aspect of the head, the palatal portion being inclosed within the mouth in consequence of the elongation of the lower jaw. If now the sclerotome, of which the intermaxillary bones constitute the hæmal arch, be examined, it will be found to present superiorly the two nasal bones, as its neural elements; but which, instead of bounding along with their corresponding centrum, a neural space, assist the intermaxillary bones in forming two spaces, which are completed, and at the same time separated from one another by the centrum, which no longer separating a neural from a hæmal space, separates a pair of lateral neurohæmal spaces, or nostrils, from one another. This modification of the sclerotome depends, primarily, on its not being required to enclose a segment of the neural axis; and, secondarily, on its co-operating in the formation of the nostrils. This form of sclerotome, in which the centrum passes from above downwards, I denominate catacentric, to distinguish it from the ordinary form in which the centrum passes across, which, therefore, I also occasionally find it convenient to indicate as the diacentric form of sclerotone. The passage from the diacentric to the catacentric form is exemplified in the ethmoidal sclerotome, the hæmal arch of which, consisting of the pair of maxillary bones, enters into the formation of the nasal passages. The centrum of this sclerotome has assumed the form of a more or less compressed plate, which, while it retains its lateral connections with the neurapophyses, extends at the same time more or less upwards into the neural space, and downwards between the nostrils, which, under this sclerotome and the one behind, consist of a mesially bisected hæmal cavity.

The anterior terminal sclerotome in the non-proboscidian Mammals is cartilaginous and catacentric. Its neuro-hæmal chambers are closed in front by the junction of the anterior margins of its neural and hæmal elements. In consequence, too, of the position of the external nostrils, which, as metasomatomic openings, are situated between the hæmal elements of this sclerotome and those of the sclerotome immediately behind, its hæmal elements are tilted forwards, so that towards their junction with the neural elements, their sternal margins are continuous with the dorsal line of the nose. In the more developed forms of this sclerotome, from one to three hæmactinapophyses on each side enter largely into its arrangements.

In the proboscidian Mammals, instead of being greatly developed, as might naturally be expected, this sclerotome is, on the contrary, much simplified. In the Tapir the hæmapophyses have disappeared, while in the Elephant, the neurapophyses alone exist in a comparatively undeveloped form. I believe, however, that it will ultimately be admitted, that the proboscis is not a mere elongation or development of the external nose, like the pseudo-proboscis of the Bear, Racoon, and Coati, but a syssomatome.

Second general form of deterioration of the Sclerotome at the front of the Head. The character of this form of deterioration may be best observed in the intermaxillary or vomerine sclerotome of the osseous Fish. Instead of being reserved for the purpose of forming portions of nostrils, the neural space no longer required for the lodgment of a segment of the neural axis disappears entirely, the neurapophyses being at the same time generally absent. The centrum may also disappear, or may exist in the form of a cartilaginous nodule; a pair of neurapophyses may therefore form the entire sclerotome. These hæmapophyses generally extend outwards and downwards from one another, or from the centrum if it exists at the mesial plane. They form together, therefore, an arch suspended at its centre, with its piers unsupported. The hæmapophyses of the two sclerotomes immediately behind, form respectively two arches, the maxillary and palatal, suspended by their centres from the base of the skull. The centres of these three arches are, however, morphologically their approximated piers, the actual centres, their sternal or hæmal conjunctions are not completed in the osseous Fish, in consequence of the nonformation of the nasal fossæ. These three incomplete hæmal arches retain their embryonic form of imperfect visceral laminæ. They do not bridge across to form a palate, and therefore the first complete hæmal arch in the osseous Fish is the mandibular. The palate in it is, therefore, like that of the Mammal, morphologically a portion of the external surface of the animal. But they differ from one another in this respect, that the palate of the Fish is a primary, that of the Mammal a secondary surface.

Number of Sclerotomes in the Vertebrate Head.—It has tended not a little to throw discredit on the vertebral theory of the skull, that its advocates have differed much as to the number of its constituent vertebræ. I am inclined to think, that these discordant views are the result of a tendency in later inquirers to be influenced by that *à priori*, or "transcendental" method, characteristic of those German and French anatomists with whom the subject originated. For my own part, so far from coinciding in the received opinion, that the number of segments in the vertebrate head is the same in all its forms, I believe that it varies. I shall state in the sequel the grounds on which I hold the number of sclerotomes to vary slightly in the heads of the ordinary forms of vertebrata. I am, however, inclined to believe, that there are indications afforded by embryology and comparative anatomy, of the existence in certain forms of vertebrate head of a considerably greater number of sclerotomes than has been generally supposed. I base this conjecture, first, on the system of cartilaginous nasal segments in the Cyclostomes; and, secondly, that if the head is to be distinguished embryologically from the trunk, by the presence of "visceral laminæ" separated by clefts, then not only the Cyclostomes, but the still more remarkable Branchiostoma indicate a number of cephalic segments, and a form of vertebrate structure, of which, in the present state of the science, it can only be said, that such a form is deducible from the vertebrate type.

I recognise in the head of the Fish, exclusive of the Cyclostomes, six sclerotomes; in that of the Amphibian and Reptile also six; with the exception of the Crocodiles, in which the seventh is feebly developed; in that of Birds, six; and in that of Mammals, exclusive of the Proboscidians, seven.

I find it more convenient to examine these sclerotomes from before backwards; and I distinguish them provisionally by the following designations—

1. RHINAL.
2. VOMERINE.
3. ETHMOIDAL.
4. PRE-SPHENOIDAL.
5. POST-SPHENOIDAL.
6. TEMPORAL.
7. OCCIPITAL.

Keeping out of view, therefore, the Cyclostomatous Fishes and the Proboscidian Mammals, which present indications of a greater number, the Vertebrata generally possess all the sclerotomes enumerated above, except the Rhinal, which exists only in Mammals and Crocodiles.

On a fundamental difference between the cranium of the Mammal, and that of the Bird, Reptile, Amphibian, and osseous Fish.—In my earlier attempts to unravel the intricacies of this subject, I found myself opposed by difficulties in passing from the Mammalian to the lower form of cranium, and *vice versa*. I afterwards discovered, that this mainly depended on the reciprocal development and atrophy of the meta-neurapophyseal elements of four sclerotomes in the two forms. In consequence of this, we had been hitherto confounding the frontal bone, or meta-neurapophysis of the ethmoidal sclerotome of the Mammal, with the so-called "proper frontal bone," which is in fact the meta-neurapophysis of the pre-sphenoidal sclerotome of the Bird, Reptile, Amphibian, and osseous Fish, an element of which there are, and this only in rare instances, faint or doubtful traces in the former; and *pari passu*, we had been confounding the parietal bones, the double meta-neurapophysis of the post-sphenoidal sclerotome of the Mammal, with the so-called parietals, the largely developed meta-neurapophyses of the temporal sclerotome of the Bird, Reptile, Amphibian, and osseous Fish, elements which are much reduced in size, and masked in the former. Among other important organic relations indicated in the existence of these two forms of cranium, I would here more particularly note their bearing on the encephalon. Of the two forms, that of the Fish, Reptile, and Bird, while it adheres to the common type, is modified mainly in relation to the organs of smell, sight, and hearing. That of the Mammal, also adhering to the common type, is modified in relation to the cerebrum proper—to that nervous structure superimposed upon the series of ganglionic masses at the base of the brain which are serially homologous with the spinal cord.

RHINAL SCLEROTOME—*In Mammals.*—The principal parts of the cranium which remain unossified in the Mammal are the nasal septum and the cartilages of the nose. Of these, the unossified portion of the nasal septum is the anterior prolongation of the basal portion of the so-called "primordial cranium." It is consequently a continuous mass of cartilage, but is nevertheless referable to three sclerotomes; its superior portion completing the centrum of the ethmoidal; its lower portion, the centrum of the vomerine; and its anterior, that of the rhinal sclerotome.

The rhinal sclerotome in the Mammal is fibrous, cartilaginous, and catacentric. Its centrum, formed by the anterior portion of the nasal septum, extends from its neural to its hæmal margin. Its right and left neural elements are the so-called superior or triangular cartilages of the nose. They may be continuous with or merely attached to the neural edge of their centrum. The anterior margins, or angles of these cartilages, and the corresponding point of the septum or centrum is the absolute anterior termination of the animal, or more precisely of its morphological axis. The ridge of the nose downwards and forwards to that point is neural or dorsal; beyond it, although continued in the same line, the ridge is hæmal or sterual.

The two alar cartilages are the hæmapophyses of this sclerotome. Variously modified in form, they are more or less firmly attached to the lower margins of the upper cartilages. In front they are attached to the septum, to which also they are more loosely connected round the tip of the nose, being frequently folded in on the ridges of the septum. In the fibrous membrane occupying the sides of the space between the posterior margins of the alar cartilages which together constitute the hæmal arch of their sclerotome, and the anterior margins of the intermaxillary bones which form the hæmal arch of the succeeding sclerotome, there are generally a number of variously modified cartilaginous pieces. These pieces are teleologically highly important elements of the rhinal sclerotome. Morphologically they are actinapophyses. When fully developed, they are three on each side attached to the alar cartilage. In the Ox and other Ruminants, the superior actinapophyses is an irregular lamina, which, imbedded in the fibrous membrane, assists in supporting the wall of the nostril. The second is a thick, short bar, articulated to the alar cartilage in front, and jointed behind to the corresponding element of the vomerine sclerotome, by which arrangement it is immediately connected with the inferior turbinal bone, which is an actinapophyseal element of the ethmoidal sclerotome. The third or inferior rhinal actinapophysis is a crutch-like cartilage, articulated to the alar element by its stem, which is bent inwards, then downwards, and outwards to the margin of the nostril, which it supports by its curved transverse portion. In the Bear, Racoon, and Coati, the two superior actinapophyses are much developed, and, along with the neurapophyseal, form the cartilaginous wall of the trunk-like nose, or pseudo-proboscis. In the Phacochoer the acuminated nasal bones curve down toward the intermaxillary, so as to separate the neural elements of the rhinal sclerotome from one another. The rhinal centrum is therefore much diminished in extent; but is, at the same time, strengthened for the support of the nasal buckler by a deposit of bone. The hæmapophyseal and actinapophyseal elements are thus pushed outwards, along with the nostril, so as to produce that breadth for which the snout of this Pig is remarkable. In Man the rhinal actinapophyses are reduced to the sesamoid cartilages. In the Solipeds they disappear altogether. The so-called semilunar cartilage of the Horse is, in fact, the alar cartilage itself, the internal inferior angle of which, much elongated, supports the inner margin of the nostril, as the transverse limb of the crutch-like inferior actinapophysis of the Ruminant, supports the outer margin of the orifice.

The rudimentary Rhinal Sclerotome in the Crocodiles.—In the Crocodiles, as in the Mammalia, the vomerine sclerotome is traversed by the nasal fossæ, which open therefore in front, instead of behind it, as in the other Reptiles and in Birds. It is evident, therefore, that if the Crocodiles do not possess, like the Mammalia, a rhinal sclerotome, their external nostrils must present an exceptional arrangement; for, instead of being metasomatomic, they must be terminal. I find, however, that in the Alligator, the hoods which extend from the anterior inner margins and septum of the osseous external nostrils consist of dense fibrous tissue, covered by the muscles which act upon them. This double fibro-muscular hood is so arranged on each side as to have the oblique slit-like nostrils situated between their outer margins and the intermaxillary edges. If a plate of cartilage were developed in the margin of each hood, the whole arrangement would occupy the position, and exhibit the relations of an ali-nasal cartilage—a rhinal hæmapophysis, or neurapophysis, as in the Elephant.

VOMERINE SCLEROTOME—*In Mammals.*—In the Mammal the vomerine is a perfect catacentric sclerotome. The nasal bones are its neural elements, as they occasionally run together, and are evidently, as has been generally admitted, serially homologous with the frontals and parietals; they must be viewed as meta-neurapophyses, the neurapophyses being absent in the absence of a nervous centre. The intermaxillaries meeting below form the hæmal arch, and the centrum consists of the vomer, with a corresponding portion of the cartilaginous nasal septum.

The vomer is a bone peculiarly Mammalian. It may be said to make its appearance as a developed element, along with the completed nasal fossæ. But its development in the Mammalian series is not only dependent on the nasal fossæ, but on the intermaxillaries, with which, as will be shown in the sequel, it is invariably connected. Its passage backwards under the centrum of the ethmoidal sclerotome to abut against that of the pre-sphenoidal, is, as will also appear, a Mammalian peculiarity, and an instance of that antero-posterior elongation and of that overlapping arrangement so frequent in the adaptation of the cephalic centrums to one another.

When the inferior turbinal bone, an actinapophysis of the ethmoidal sclerotome, is highly developed, as in the Ruminants, a strong flattened bar of fibro-cartilage is attached to the inner aspect of the ascending process of the intermaxillary, and widening out into a soft curved cartilaginous plate, completes the fore part of the inferior turbinal connecting it at the same time to the second actinapophysis or turbinal process of the ali-nasal cartilage. I look upon this appendage as a hæmactinapophysis of the vomerine sclerotome; and serially homologous with the second or turbinal hæmactinapophysis of the rhinal, and with the turbinal hæmactinapophysis of the ethmoidal sclerotomes.

These hæmactinapophyses have all of them been enclosed within the nasal chamber during development; having passed in through the meta-sclerotomic clefts, instead of forming parts of the nasal wall, or projecting from its outer aspect.

Vomerine Sclerotome in the Crocodiles.—It is remarkable that the familiar fact of the peculiar position of the external nostrils of the Crocodiles should not hitherto have attracted attention. They open in front of the intermaxillaries as in the Mammals; whereas, in the typical Lacertians, and in the extinct Plesiosaurs, Icthyosaurs, and Pterodactyles, in the Ophidians, Amphibians, and Birds, they open behind these bones. On this peculiarity in the Crocodiles depends the very perfect development of the anterior part of the nasal septum. Along with the complete and pervious intermaxillary arch, we find a complete although cartilaginous vomer. Of that part of the extended nasal septum of the Crocodiles, corresponding to the Mammalian nasal septum, the only ossified portion is an elongated single or double slip along the lower edge of its ethmoidal region, and continuous with the elongated presphenoidal centrum. Professor Owen considers this slip of bone as the vomer. I will only observe at present, that holding the vomer to be invariably in relation to the intermaxillaries, I can only conceive, as the vomer in the Crocodile, that elongated cartilaginous portion of the nasal septum which extends beneath the elongated nasal bones to the intermaxillary suture.

Vomerine Sclerotome in Typical Lacertians.—In the proper Lizards this sclerotome is imperforate. The intermaxillaries not only close in at the palate, but in front also; the more or less elongated and combined ascending processes joining the united or distinct nasal bones. The centrum is represented by the anterior part of the cartilaginous septum. The two bones usually described as the double vomer of the Lizard belong, as I shall endeavour to show in the sequel, to the succeeding sclerotome —the ethmoidal.

Vomerine Sclerotome in Birds.—The vomerine sclerotome of the Bird consists principally of the intermaxillaries, but partly of the persistent anterior portion of the primordial cranium. The intermaxillaries speedily unite below and in front, so as to form the first and principal part of the beak. Their united ascending processes extend up to the so-called "principal frontal bone," and separate completely the so-called nasal bones. In the sequel the evidence will be adduced on which I found my belief that the bone called in Birds the "frontal," or "principal frontal," is not the frontal of the Mammal; but that the two so-called nasal bones in the Bird are the two halves of that bone which in the Mammals is called frontal. If so, where are the nasal bones of the Bird? as the ascending processes of their intermaxillaries, which occupy the proper position of the nasals, have not been observed as separate centres of ossification; and as the greater number of Chelonian Reptiles want these bones, and resemble Birds in the general character and horny covering of their beaks, I am inclined to believe that the nasal bones are deficient as ossified elements in the Bird. In young birds, after boiling or maceration, the osseous elements of the beak may be removed, and the anterior part of the primordial cranium brought into view. In the forepart of its septum we again recognise the vomerine centrum, but more or less deficient in certain Birds from the septal perforation peculiar to them. The upper margin of the cartilaginous septum, where it is in contact with the ascending processes of the intermaxillaries, flattens out into a lamina, which partly roofs over the external nostril on each side. These marginal processes of the cartilaginous vomerine centrum extends down in front, so as to line the fore and under part of the nasal fossæ, projecting somewhat behind the intermaxillary margin of the external nostril.

The broad projecting upper portion of the cartilaginous septum occupies the position of the nasal bones, while the inferior portions project from behind the intermaxillaries, like opercular actinapophyses. In the Chick the part of the primordial cranium just described as belonging to the vomerine sclerotome, presents an opaque aspect and fibro-cartilaginous structure, contrasting with the hyaline cartilage posterior to it—a peculiarity pointed out by Reichart as characteristic of certain portions of the primordial cranium. It will be observed that I do not consider the bone or bones usually called "vomer" in the Bird as correctly designated. In the sequel I shall indicate the grounds on which I hold these bones to be the upper elements of the palatine arch.

The Vomerine Sclerotome in Chelonian Reptiles.—The intermaxillaries in the Chelonian, united below, complete the front of the palate alveolar margin, and floor of the nasal fossæ. The only trace of ascending processes which they present, is a compressed spine which projects upwards at their junction in the median line of the nasal opening of the cranium. The lateral margins of that opening are formed by the maxillaries alone; its upper margin by the so-called pre-frontals, except in Hydromedusa and certain fossil forms. The cartilaginous septum of the nasal fossæ extends up from the intermaxillary suture to that of the pre-frontals.

Is the Chelonian vomerine sclerotome modelled on that of the Crocodile, or of the Bird? The Chelonian presents the first stage in the remarkable development of the nasal passages exhibited by the Crocodiles. But the general deficiency of the nasal bones, the indications of ascending processes of the intermaxillaries in the mesial plane, the formation of the posterior margins of the external nostrils by the maxillaries, appear to me to show that in the construction of its vomerine sclerotome, the Chelonian differs from the Crocodiles, and resembles the typical Lacertians, the Ophidians, Amphibians, and the Birds. The cartilaginous lining of its nasal fossæ, a remnant of its primordial cranium, projects, in general, a little beyond the margins of the osseous nostrils, as in Birds; but in Trionyx and Chelys, the projecting margins run forward together in the form of a double cartilaginous proboscis.

The Vomerine Sclerotome in the osseous Fishes.—I have already described the general constitution of the vomerine sclerotome of the osseous Fish, as one form of deterioration of the forepart of the cranium. Its centrum, the vomer, when it is present, is merely a cartilaginous nodule in the longitudinal axis of the basis of the cranium, in front of the bone usually described as the "vomer," but which I believe to be the centrum of the ethmoidal sclerotome,—the neural elements, and those scale-like bones, which Cuvier recognises, I believe correctly, as the nasals. Professor Owen considers these bones to be the turbinal divisions of the olfactory "sense capsules"; and, according to his doctrine of the sense capsules, elements of the splanchno-skeleton. If Professor Owen understands by the turbinal divisions of the olfactory sense capsules, bones homologous with the inferior turbinated, or even the so-called ethmoidal turbinated bones of the Mammal, it is difficult to understand, on embryological principles, how, as splanchnic bones, and as developed in connection with the maxillaries, they come to be situated under the integument of the upper surface of the head. It is, moreover, questionable, whether the sclerous capsule of this, or of any of the special sense organs, is ever divided, and its parts separated from one another, under such relations as those presented by the so-called "turbinals" and "ethmoidal" of the osseous Fish.

The intermaxillaries form the principal and more peculiar elements of this form of vomerine sclerotome. The nasal fossæ being entirely absent, the merely fibrous olfactory sense capsule is subcutaneous, or partly under cover of the nasal bones (turbinals); the vomer is not developed as a septrum, but merely to supply a fulcrum for the intermaxillaries, which may even constitute the entire sclerotome, but are never united below, so as to form a complete hæmal arch.

THE ETHMOIDAL SCLEROTOME.—The ethmoidal sclerotome, and the pre-sphenoidal immediately behind it, present, in the different forms of Vertebrata various remarkable modifications of their elements, partly dependent on the position of the olfactory lobes of the brain, partly on the position of the olfactory capsules themselves, partly on peculiar adjustments of the nasal fossæ, and on the arrangements subservient to mastication.

The withdrawal from behind forwards of the neural axis, in the course of development, from the posterior extremity of the neural canal is accompanied by well-known changes in the evacuated, but rapidly increasing posterior trunk sclerotomes. Corresponding, but much more remarkable changes, to which attention has not been hitherto sufficiently directed, accompany the withdrawal from before backwards of the anterior part of the brain from the ethmoidal and pre-sphenoidal sclerotomes. The neural portions of these sclerotomes assume more or less of the catacentric character—they become demicatacentric. The neural chamber of the ethmoidal sclerotome of the Mammal, in addition to a portion of the cerebrum proper, lodges its homologous segment of the neural axis. In the Bird the neural chamber of this sclerotome is completely evacuated by the neural axis, which not only leaves it, but withdraws in part also from the pre-sphenoidal. The absence of the anterior extremity of the neural axis from the neural chamber of the ethmoidal sclerotome, is accompanied by the division of that chamber into a right and left compartment by a mesially laminar centrum, the two compartments being occupied by the olfactory capsules. The olfactory lobes in the Bird are not only withdrawn from the ethmoidal sclerotome, but retreat to a certain distance backwards in the neural chamber of the pre-sphenoidal. To this extent the chamber becomes catacentric; but instead of its two resulting compartments being occupied by new structures, having only to transmit the olfactory nerves, their outer walls collapse upon the mesially laminar centrum, and very generally disappear almost altogether, so as to leave the nerves uncovered on the sides of the laminar centrum as they pass forward to the ethmoidal chambers. The neural chamber of the ethmoidal sclerotome of the Bird, containing only the olfactory capsules, is so connected with the bones of the face, and with the neural arch and centrum of the pre-sphenoidal, as to be more or less moveable along with the lower mandible. The ethmoidal in the Mammal is thus seen to be the anterior cerebral sclerotome, while in the Bird it becomes the posterior facial sclerotome.

In the Reptile both the ethmoidal and pre-sphenoidal sclerotomes are evacuated by the neural axis, the olfactory nerves alone passing along in the compressed tubular, partially-catacentric neural chamber of the latter—the olfactory capsules occupying the right and left chambers of the former. In Reptiles, however, the very varied forms assumed by the bones of the face, and more particularly by those of the palatine arch, in relation to the nostrils, and the arrangements for mastication, produce numerous remarkable modifications of these two sclerotomes.

In passing from the Reptile to the Fish, the ethmoidal sclerotome may be said to gather together its scattered elements, and to present a centrum and neural arch frequently as compact as the Human; but modified by the deficiency of nostrils, and by the withdrawal of the neural axis.

Ethmoidal Centrum and Neural Arch in the Mammal.—The human cranium, as the most perfect in the higher of the two forms of skull, will not unfrequently be found to afford a clue to the signification of bones which, being only applied to their final purposes in it, are more or less masked in the other Mammalia, and apt to be misunderstood altogether in the Fish, Reptile, and Bird. If we examine in connection the two bony masses, which, in the current nomenclature of Human Anatomy, are distinguished as frontal and ethmoid, they will be seen to constitute a ring, the space within which is greatly dilated behind, in consequence of the vast expansion, more particularly of the upper and lateral portions of the frontal; while it is diminished to a tubular chink in front, and is so indistinct towards the nasal fossæ, that the older anatomists named it "foramen cæcum." The development of this bony ring shows it to consist of five pieces. These are, the mesial plate, including the crista-galli of the ethmoid, the lateral masses of the same bone, including the corresponding halves of the crebriform lamina, and the two halves of the frontal. We have here therefore a centrum, a pair of neurapophyses, and a divided meta-neurapophysis. The pair of olfactory nervous centres, which terminate in front the entire series of segments of the neural axis, are the segments of that axis, homologous with this neural arch and centrum. In the Mammalia only, is the upper part of this neural arch expanded and adapted for the protection of the more or less developed forepart of the cerebrum proper. In the central portion and lateral masses of the ethmoid, and in the frontal bones of the Mammal, I recognise the centrum and neural arch of a sclerotome, which I provisionally distinguish as the ethmoidal.

Centrum and Neural Arch of the Ethmoidal Sclerotome in the osseous Fish.—The more or less concurrent statements of Oken, Bojanus, Geoffroy, Cuvier, and Owen, as well as the relations of the bones themselves, leave no doubt as to the homology of the so-called pre-frontals of the Fish. They are neurapophyseal elements, the lateral ethmoidal masses of the Mammal in another form, and *minus* the ossified olfactory capsules. The median bone superimposed upon the "pre-frontals" of the Fish, and which has been very generally held to be the united nasals, and the spine of the olfactory vertebra, must be homologous with the frontal bone of the Mammal, if its relations to the "pre-frontals" and olfactory nerves of the former are compared with those of the ethmoid and frontal bones, and the olfactory nerves of the latter. Professor Owen, while he adopts the determination of the superior median bone, as the united nasals, also holds by the hitherto unanimous opinion of anatomists, that the median bone armed with teeth, situated below the pre-frontals of the Fish, is the vomer. Guided by the ethmoid of the Mammal, I cannot see in this bone aught else than the homologue of the central element of the Mammalian ethmoid. The vomer is a Mammalian bone; if it appears in the Fish at all, it is a cartilaginous or semiossified nodule between the intermaxillaries. That the centrum of the ethmoidal sclerotome in the Fish, considered as the homologue of the central plate or bar of the Mammalian ethmoid, should carry teeth in the Fish, is not more remarkable than that one of the centrums of the cervical vertebræ in that class of animals should be so armed.

Hæmal Arch of the Ethmoidal Sclerotome in the Mammal and osseous Fish.—I have commenced my account of the morphological constitution of this important sclerotome, by pointing out the typical arrangement which its neural arch and centrum present in the Mammal and Fish. As the arrangement of these parts of this sclerotome becomes much and variously modified in Birds, Reptiles, and Amphibia, in relation to the various forms presented by the organs of smell and the nostrils, it will be necessary, before proceeding farther, to examine the constitution of its hæmal arch. Even in its most complex form, this hæmal arch, like those of the rhinal and vomerine sclerotomes, consists of two elements only, the right and left maxillary bones. In the osseous Fish they resemble the "lateral frontal processes" in the embryo; they form only an incipient arch like that formed by the vomerine hæmapophyses in front of them. They do not invariably carry teeth. They are variously connected to the hæmapophyses before and behind them; and superiorly to the lateral and forepart of the centrum, neurapophyses, and meta-neurapophyses of the neural arch of their own sclerotome.

The maxillaries of the Mammal, more or less extended from before backwards, and increased in breadth and depth to adapt them to their functions in mastication; meeting one another below, to form a great part of the vault of the palate, and to assist in the formation of the nasal passages; hollowed out to combine lightness with strength; and buttressed by numerous connections with neighbouring bones, nevertheless retain their connection with the neural portion of their own sclerotome, being attached superiorly to the lateral masses of the ethmoid, and to the frontal. They are not articulated, as in the Fish, to their centrum; but those connections to the neurapophyses and meta-neurapophyses, which in Fish are affected by ligaments, are sutures in the Mammal. In the sequel it will be shown, that of the two connections of the maxillary, that to the frontal, and that to the lateral ethmoid, the former is the most constant; presenting in my opinion the fundamental discriminative character of the remarkably modified frontal of the Bird, Reptile, and Amphibian.

The Ethmoidal Sclerotome in the Bird.—The ethmoidal sclerotome is remarkably modified in the Bird. It forms no part of the cranium proper, but assumes the position and structure of a facial sclerotome. The Bird, like the Mammal, has two proper facial sclerotomes. In the former, there are the vomerine and the ethmoidal; in the latter the rhinal and vomerine. In the majority of Birds, also, the ethmoidal sclerotome, along with the vomerine, moves more or less freely on the presphenoidal. It is, moreover, peculiar in being chiefly devoted to the economy of the organs of smell; in having its meta-neurapophyseal elements separated from one another by the passage backwards of the conjoined ascending processes of the intermaxillaries; in the feeble development of its hæmapophyses; and in its cavities being altogether neural, its neurapophyseal elements forming more or less of its palatal aspect.

The meta-neurapophyses of the ethmoidal sclerotome of the Bird, are the so-called nasal bones. From their invariable connection with the maxillaries, I cannot see in these "nasal bones," aught else than the proper frontal bones—the frontals of the Mammal. They are separated from one another by the ascending processes of the intermaxillaries; a circumstance which does not militate against their being the right and left halves of a meta-neurapophyses. They are more or less elongated in the antero-posterior direction; and they bound the posterior margins of the external nostrils by the descending processes which connect them with the maxillaries. To distinguish them from the meta-neurapophyses of the pre-sphenoidal sclerotome, I designate them ethmoido-frontals.

The arrangement of the centrum and neurapophyses of this sclerotome in the Bird, appear to me to have been in a great measure overlooked, from having been examined in the macerated skull, in which these parts, as consisting principally of cartilage, are to a great extent absent.

The centrum consists of the posterior and greater part of the mesial cartilaginous lamina, the interior portion of which forms the vomerine centrum. The ethmoidal portion of this laminar mesial cartilage flattens out at its upper margin, in the same manner as the vomerine portion in front; and like the flattened upper edge of the so-called "ethmoid bone,"

—the centrum of the pre-sphenoidal sclerotome behind. In the same manner as the flattened upper margin of the vomerine portion extends outwards on each side, so as to form a hood over the upper and forepart of the external nostrils, the flattened upper margin of the ethmoidal portion of the septum passes outwards on each side, under cover of the ascending processes of the intermaxillary, and under the ethmoido-frontal, extending down more or less to the level of the palatal plate of the maxillary, and then turning in towards the mesial plane, approaches or meets the lower margin of the mesial lamina itself. Posteriorly, these curved cartilaginous plates close in upon the posterior margin of the septum; which is not continuous with the anterior margin of the laminar septum of the pre-sphenoid. They are each, however, perforated or notched for the transmission of the olfactory nerve; and they also leave on each side of the septum at their posterior inferior angles, a space for the posterior nasal orifice. The superior and middle turbinated folds of the nasal chamber on each side, are also supported by turbinated cartilaginous projections from the internal surfaces of their plates.

I have already stated that the anterior fibro-cartilaginous portion of the persistent part of the primordial cranium of the Bird enters into the structure of its vomerine sclerotome; it will now be observed that its posterior hyaline portion enters into the formation of the ethmoidal sclerotome. In the majority of Birds, the septal lamina continues cartilaginous, as well as the greater part of the curved lateral plates, with their internal turbinal projections. A more or less extended portion only of each curved plate becomes ossified when it extends inwards across the palate; and the ossified portion becomes anchylosed to the maxillary, or to the descending maxillary process of the ethmoido-frontal (" nasal"), and in many Birds to the anterior extremity of the palate bone.

I recognise, therefore, the posterior part of the nasal septum as the centrum; the so-called "nasals" as the meta-neurapophyses; and the more or less ossified lateral and inferior walls of the olfactory chambers as the neurapophyses of the ethmoidal sclerotome of the Bird. If it be objected to this determination, that the parts which I consider as neuropophyses, are only portions of the olfactory sense capsules, I would merely observe, that these sense capsules are in fact combined with the neurapophyseal portions of the ethmoidal sclerotome in the Bird, as in the primordial cranium of the Mammal, Reptile, and Amphibian, and as in cartilaginous Fishes; but that this circumstance in no way nullifies the existence of the neurapophyseal element itself, either in the sclerotome with which the olfactory capsules, or in those with which the ocular and auditory capsules, are connected. I would also observe, that I base my determination of the neurapophyseal character of these parts, not merely on their relations in the Bird, but on the varied relations exhibited by their corresponding parts in Reptiles.

The maxillaries or hæmapophyses of the ethmoidal sclerotome are feebly developed in the Bird. Connected above, chiefly to the descending processes of the ethmoido-frontals, and more or less prolonged in the antero-posterior direction, the maxillaries do not invariably complete the hæmal arch. Their region, therefore of the palate, is more or less completely occupied by the neurapophyseal plates of their own sclerotome.

The Ethmoidal Sclerotome in the Chelonian.—The connection of the maxillaries of the Tortoises and Turtles, by means of the ascending processes of these bones, with the so-called pre-frontals, appears to me to indicate that the latter are homologous with the ethmoido-frontals of the Bird, or the frontals of Mammalia. I recognise in them the meta-neurapophyses of the ethmoidal sclerotome. Each of these bones sends down from its posterior margin a lamina, concave in front, and forming with the concave under surface of the bone itself, the posterior superior hollow of the nasal fossa. The inner margins of these two descending laminæ give attachment to the anterior margins of the fibro-cartilaginous laminæ, which bound laterally the compressed pre-sphenoidal neural space, and form the so-called interorbital septum. The inner margins of the two descending frontal laminæ are, therefore, separated from one another above by the breadth of the forepart of the groove on the mesial part of the under surface of the combined so-called "frontals." If now the macerated skull of the Turtle be examined, it will be found that a complex bony piece, the so-called "vomer," connects by its pair of short divergent upper processes the inferior extremities of the inner margins of the descending frontal processes, converting the space between them into a triangular orifice. This so-called vomer, after sending a horizontal plate backwards between the palatines to form the mesial portion of the common orbital floor, and to support the cartilaginous bar-like centrum of the pre-sphenoid, passes down as the osseous septum of the posterior nares, and terminates in the form of a pentagonal plate in the palate, between the palatines and maxillaries, and in some species in a hexagonal form, between the palatines, the maxillaries, and inter-maxillaries. The relations of the ethmoidal neurapophyses to their meta-neurapophyses in the Bird, and the presence of the former in the maxillary region of the palate, led me to suspect that the so-called "vomer" of the Turtle is the combined neurapophyses of its ethmoidal sclerotome. But its posterior horizontal laminar process, which supports the cartilaginous pre-sphenoidal centrum, as well as the process which forms the septum of the posterior nares, indicated the probability of the "vomer" being a still more complex bone. I have not met with the palatal plate as a separate bone in the Turtle, although in longitudinal sections I have observed faint indications of its having been so. I find, however, that in certain Tortoises, not only is the palatal plate connected by a distinct suture to the upper portion of the so-called "vomer," but it is divided by a similar suture in the mesial line of the palate into two halves. In these Tortoises, therefore, the separation of the posterior nares, the junction of the descending processes of the ethmoido-frontals, and the support of the cartilaginous bar-like centrum of the pre-sphenoid, are affected by a distinct bone, which, including its connections to the palatines, presents all the characters of the so-called "vomer" of the Bird. But I have already stated my belief, that the bone so-called is not the vomer of the Bird; and in the sequel I shall state the grounds on which I hold it to be the combined entopterygoids—the upper elements of the palatine arch.

Ethmoidal Sclerotome in the Crocodiles.—In the Crocodiles proper, and the Gavials, the lachrymal is interposed between the so-called pre-frontal and the maxillary. In the Alligators the maxillary resumes its connection with the pre-frontal, which it had lost in the two other families on account of the elongation of the snout. The pre-frontals in all the Crocodilians are separated from one another mesially by the passage backwards of narrow contiguous processes of the nasals, and by similar processes which pass forwards from the so-called "proper frontals"—in this respect resembling the so-called "nasals" of the Bird, which are separated from one another by the ascending processes of the inter-maxillaries.

Assuming the relations of the pre-frontals of the Crocodilian to the maxillary arch as evidence of their being the meta-neurapophyses of the ethmoidal sclerotome—that is, collectively, the homologue of the Mammalian frontal—the next elements of this sclerotome to be determined are its neurapophyses. At this point the type of ethmoidal sclerotome exhibited by the Bird, and the modification of that type presented by the Chelonian, indicate its character in the Crocodilian. The descending processes of the pre-frontals of the Crocodiles are connected inferiorly to the ascending processes of the so-called "palate bones." Now, a bone connected to the homologue of the Mammalian frontal cannot well be considered as the palate bone, even although it be situated between and united by suture to the maxillary and pterygoid. But a bone with such relations, if viewed in the light of the corresponding relations of the ethmoidal neurapophyses of the Bird, indicates its own real nature. The ethmoidal neurapophyses of the Bird, connected above with the ethmoido-frontals, form below more or less of the palatine vault. The ethmoidal neurapophyses of the Chelonians, pushed away forwards and downwards from the ethmoido-frontal by the ento-pterygoid, still form a part of the vault of the palate. In like manner I recognise, in the so-called "palate bones" of the Crocodilian, the neurapophyses of its ethmoidal sclerotome. The ethmoido-frontals and neurapophyses of the Bird, form, along with their cartilaginous septum or centrum, a complete catacentric neural ring. The interposition of the ento-pterygoid of the Chelonian separates the meta-neurapophyses from the neurapophyses of the ethmoidal sclerotome, and at the same time separates the neural space into an upper portion, mesially divided by the cartilaginous septum or centrum for the passage of the olfactory nerves, and into an inferior, mesially divided by the ento-pterygoid itself for the right and left nasal passages. A similar but somewhat modified change is effected in the ethmoidal sclerotome of the Crocodilian, by the interposition of the anterior extremities of its pterygoids—which anterior processes I believe to be, in fact, the ento-pterygoids. These anterior, generally mesially united, processes of the pterygoids of the Crocodilian, were considered by Cuvier as representing the under portion of the Mammalian vomer. He describes them as two osseous pieces fixed to the inner margins of the "palate bones," in front of the "anterior frontals," and of that part of the pterygoid which covers the nasal canals. Professor Owen describes these pieces as the "vomer," and as being generally anchylosed to the forepart of the basi-sphenoid; but he adds the following very important observation, which I have verified, that they (the "vomer") form a distinct bone in a species of Alligator, which passes so far forward and downwards as to appear in the form of a plate in the vault of the palate, in front of the palate bones.

That this double bony splint is not a vomer, as Cuvier supposed, must be evident, if the vomer is to be considered as an element of the vomerine sclerotome. It cannot be, as Professor Owen states, a vomer united to the "basi-sphenoid;" because, in front of the elevated, laterally-compressed, quadrilateral process which passes forwards and upwards from the centrum of the post-sphenoid, the real axis of the skull is continued forward in the form of a compressed cartilaginous bar, which is the centrum of the pre-sphenoid, and which passes in front into the cartilaginous nasal septum, which constitutes the ethmoidal and vomerine centrums. The Crocodilian and Chelonian skulls are, in fact, entirely destitute of ossified central elements in front of their post-sphenoidal centrums, the superincumbent framework in these forms of cranium being supported along the base, not by ossified centrums, but by greatly expanded and modified pterygoids, ento-pterygoids, ethmoidal neurapophyses, maxillaries, and inter-maxillaries, immediately above which series of bones lies the persistent central axis of the primordial cranium, as far back as the ossified centrum of the post-sphenoidal sclerotome. In a mesial antero-posterior section of the macerated skull of the *Crocodilus vulgaris*, a suture will be found commencing in front of the common orifice of the

Eustachian tubes, and terminating at the lower part of the root of the laterally-compressed post-sphenoidal process already alluded to. In front of this suture, the section presents no traces of central elements, the pterygoids and so-called "palatals" taking their places. In a section of this kind in the Museum of the University of Edinburgh, the extremity of the anterior process of the pterygoid passes forwards and downwards, appearing in the suture between the two "palatines," about an inch from their anterior margins; the right and left portions exposed on the vault of the palate being separated from the "palatines" by surrounding suture, and forming together a narrow double surface, one-eighth of an inch in length. In the section to which I allude, and in similar sections, I observe traces of the line of anchylosis between these anterior processes and the pterygoids themselves. These lines run upwards and forwards, and appear to include the anterior and greater part of the pterygoidal portion of the nasal septum, and the thin plate which, on each side, passes up to be united to the descending process of the "pre-frontal." In disarticulating the skull of the Crocodile the pterygoids generally remain attached to the post-sphenoidal centrum, so that the prolonged anterior processes of the former present the appearance of being elongations of the latter, which they in fact are not.

From the foregoing considerations, and on grounds to be explained in the sequel, when the palatine arch, or hæmal arch of the pre-sphenoidal sclerotome comes to be examined, I recognise in the Crocodilian vomer of Cuvier and Owen the proximal or upper element of the pre-sphenoidal hæmal arch—the same element to which, when existing in certain Fishes, Professor Owen applies the sufficiently expressive term ento-pterygoid.

It will now be observed, that in consequence of the great development of the pterygoids, and of the ento-pterygoids in the Crocodilian, the latter extending forward into the neural space of the ethmoidal sclerotome roof over the greater part, and provide a septum for nearly the whole of that extent of the nasal fossæ, the sides and floors of which are formed by the so-called "palatals" or ethmoidal neurapophyses, and abut against the descending processes of the "pre-frontals" or ethmoido-frontals, without entirely extruding the neurapophyses from these processes, as in the Chelonian. There is another minor difference between these parts in the Crocodilian and Chelonian. In the Chelonian, as has been already stated, the ento-pterygoids having pushed the ethmoidal neurapophyses from their natural connection with the descending processes of the ethmoido-frontals, complete, by means of their ascending divergent processes, the triangular space for the olfactory nerves. In the Crocodilian, again, the descending processes of the ethmoido-frontals complete the space for the olfactory nerves, by means of a short process from each of them, which, passing inwards, meets its fellow of the opposite side a little above the junctions of the descending processes themselves with the ento-pterygoids. The space left between this transverse commissure above, the combined ento-pterygoids below, and the lower ends of the descending ethmoido-frontal processes laterally, is occupied by a prolongation forwards of the cartilaginous bar-like pre-sphenoidal centrum.

If the bones hitherto considered by comparative anatomists as the "palatines" in the Crocodilian, are in reality the neurapophyses of its ethmoidal sclerotome, the question arises—Where are the actual palate bones? This question comes to be examined in the sequel, when the hæmal arch of the pre-sphenoidal sclerotome, of which these bones are elements, is under consideration. At present I may state that the study of the crania of the Bird, Lacertian, and Ophidian, has led me to recognise as the palate bone that bone which Cuvier was induced to consider peculiar to the Lizard and Serpent, and named "os transverse" or "pterygoide externe"; and which Professor Owen also names ecto-pterygoid.

The Ethmoidal Neural Arch and Centrum in the Lacertians.—The maxillaries of the typical Lacertians are invariably connected above to the so-called pre-frontals. These pre-frontals are widely separated from one another by the anterior extremities of the so-called "principal frontals," which pass forward, and bound laterally the divided or undivided nasals. The pre-frontals bound the anterior superior angles of the orbits, sending downwards on each side a plate which separates the orbit from the nasal cavity, is more or less intimately connected with the so-called "double vomer," and with the so-called "palatines." I shall, in the sequel, state the grounds on which I hold the "palatines" of the Lizard, Ophidian, and Amphibian, to be its ento-pterygoids, and to be the homologues of the bone or bones which in the Bird are considered as the "vomer." I believe the "transverse bones" of the Lizard to be actually its palate bones, pushed backwards and outwards by the greatly developed ento-pterygoids, and of its so-called "vomer." The so-called "vomer" of the Lizard consists of two bones, which form the floor of the nostrils, separated from, but at the same time connected to, one another by the lower margin of the cartilaginous nasal septum, abutting against the intermaxillaries in front, and the so-called "palatines" or ento-pterygoids behind, and leaving a space on each side, wider behind than before, between their outer margins and the maxillaries, for the posterior nares. In some Lizards the posterior extremities of the two halves of the "vomer" are separated from the transverse descending plates of the "pre-frontals" by the interposition of the anterior extremities of the ento-pterygoids, but in others they articulate with the pre-fronto-lachrymal. Anatomists appear to have been induced to look upon these two bones in the Lizard as the two halves of the vomer, by the same circumstance which has induced them to consider the ento-pterygoids of the Bird as its vomer, viz.,—their position between the posterior nares. But the general relations of the so-called double "vomer" of the Lizard, indicate that its two halves are homologous with the ethmoidal palate-plates of the Chelonian, with the so-called "palatines" or ethmoidal neurapophyses of the Crocodilian, with the corresponding cartilaginous or osseous pieces in the Bird, and with the lateral masses of the ethmoid in the Mammal. It appears to me that the ethmoidal neural arch and centrum form a catacentric arrangement, the two compartments of which constitute the greater part of the nasal fossæ, the olfactory nerves entering through the mesially divided space between the descending or orbito-nasal processes of the meta-neurapophyses; and the posterior nares passing off on the outer sides, and between the neurapophyses and the maxillaries.

The Ethmoidal Neural Arch and Centrum in Ophidians.—The maxillaries of the Serpent are articulated or connected to the "pre-frontals." The latter are separated from one another mesially by the elongation of the nasals back to the "principal frontals." Each of the "pre-frontals," comparatively large, and anchylosed to the lachrymal, sends down a transverse orbito-nasal plate, notched on its inner margin for the olfactory nerve, but separated from its fellow of the opposite side by the pre-sphenoidal processes of attachment of the "palatines." The space roofed over by the nasals and "pre-frontals" is mesially divided above by the contiguous mesial descending laminæ of the nasals, and below by the cartilaginous nasal septum. It is floored by the double "vomer," the two halves of which, connected by the lower margin of the cartilaginous septum, extend from the intermaxillaries in front to the centrum of the pre-sphenoidal sclerotome behind, being separated from the orbito-nasal processes of the "pre-frontals" by the pre-sphenoidal processes of the "palatines."

From what has already been stated with reference to the corresponding parts in the Bird, the Chelonian, and Saurian Reptile, it will now be seen that I hold the so-called "pre-frontals" of the Serpent to be its actual frontals or ethmoido-frontals; its so-called double "vomer" to consist of the right and left neurapophyses, as the "pre-frontals" are the two halves of the meta-neurapophyses; and the cartilaginous nasal septum the centrum of its ethmoidal sclerotome.

The Ethmoidal Neural Arch and Centrum in the Amphibians.—The view which I take of these parts in the Amphibia will at once appear from the foregoing statements, and may be illustrated by the structure in the Frog. As in the Bird, the basis of the ethmoidal neural arch and centrum consists of that portion of the persistent primordial cranium which is situated behind the intermaxillary region, and immediately in front of the "os a ceinture." The mesial portion of this mass of cartilage forms the centrum of the sclerotome, as the posterior part of the nasal septum. The posterior portions of the nasal fossæ are hollowed out on its sides. Its upper surface is covered by the so-called "pre-frontals," which are, in fact, ethmoidal-frontals, or the two halves of the divided meta-neurapophysis. Its lower surface is supported by the two triangular bones, covered with teeth, and which are the neurapophyseal ethmoidal elements, already examined in the other Vertebrata. The posterior nares are situated behind, between the outer margins of these so-called vomerine bones and the maxillaries. The latter are, as usual, connected to the ethmoido-frontals.

Of the views which have been hitherto taken of the Ethmoidal, or Nasal Vertebra, or Sclerotome.—I am precluded in an abstract from entering upon the important but tangled morphological history of the nasal segment of the cranium. I shall only, therefore, on this department of the subject, make a few observations, in deference to the authority of Professor Owen, and in explanation of those points on which I find myself at variance with his doctrine. I have already so far stated, and in the sequel shall more fully state, the grounds on which I dissent from the doctrine of Oken and Bojanus, adopted by Professor Owen, that the nasals and vomer are respectively the neural spine and body of the nasal vertebra. What I intend more particularly to notice at present is that part of Professor Owen's doctrine which relates to the neurapophyseal elements of the nasal vertebra.

Professor Owen considers the middle plate of the Mammalian ethmoid to be the coalesced pre-frontals, and the two halves of the crebriform plate, the ethmoidal cellules, and turbinated laminæ, to be collectively the greatly developed olfactory capsules. If the latter are kept out of view, as not entering, according to his doctrine, into the formation of the ethmoidal or nasal neural arch, the doctrine necessitates the conversion of the laterally-placed "pre-frontals" of the Fish and Reptile into a single mesial laminar bone. Here I would observe that, overlooking, for the present, the adoption by Professor Owen of the current statements as to the identity of the "pre-frontals" of the Fish with the "pre-frontals" of the Reptile, I cannot conceive how the "pre-frontals," either of the Fish or Reptile, can be homologous with a mesial bone. Embryologically, I cannot understand how the olfactory nerves, which in the Fish and Reptiles are situated mesiad of the "pre-frontals," can become placed in the Mammal on their outer aspects. The pair of "pre-frontals" in the Crocodile or Turtle can be legitimately enough conceived as coalescing mesially into a single bone; but this change presupposes the withdrawal or obliteration of the olfactory nerves; for, otherwise, two conditions must be admitted, both of which are embryologically untenable—first, that the olfactory lobes of the Mammal are at one period in its development mesiad to the right and left halves of its central ethmoidal plate; and secondly, that the nervous and sclerous structures change places, the former passing outwards through the latter, or the latter meeting in front of the former, and passing backwards between them. But the actual facts are these:—The mesial plate, or bar, of the Mammalian ethmoid is mesial from the first; and the olfactory bulbs, or nerves, are situated from the first on its lateral aspects. The mesial plate is the prolongation forward of the central bar of the primordial cranium; it is a true vertebral centrum, and is continued onwards and downwards into the vomerine portion of the cranial axis. The cribriform lamellæ are the only parts, therefore, of the Mammalian ethmoid which present in their embryo and adult conditions all the characters of neurapophyseal elements; connected below with their centrum, and laterally or above with their frontal meta-neurapophyses, they, along with the latter, and the centrum, close in the forepart of the encephalic portion of the cranial cavity, and enclose the olfactory lobes of the brain. That the olfactory, like the fifth nerve of the Mammal, leaves the encephalic cavity by more than one orifice, and that the olfactory "sense capsules" are united to the corresponding neurapophyses, are circumstances which afford no arguments against this determination, but, on the contrary, are in accordance with the union of the auditory capsules with their corresponding neurapophyses, and the exit of the auditory nerve from the encephalic cavity in divisions. It must also be observed, that if we are to look, with Professor Owen, upon the central lamina or bar of the Mammalian ethmoid as the result of the mesial union of a pair of "pre-frontals," we must assign a morphological reason for the co-existence of a mesial cartilaginous septum with divided "pre-frontals" of the Reptile and Fish.

I am also obliged to dissent from Professor Owen's determination of the so-called "ethmoid" of the Bird as the mesially-united neurapophyses of its nasal vertebra. Apparently influenced by its usual designation, and shut up to his own view of its homology by his determination of the "basi-sphenoid" as consisting of the connate centrums of the "mesencephalic" and "prosencephalic" vertebræ, Mr Owen has in the Bird, as in the Mammal, arranged this portion of his morphological system in opposition to embryological facts. The two olfactory nerves of the Bird pass forward on each side of the so called "ethmoid" in shallow grooves; in certain instances only do they pass through notches or complete orifices formed by osseous development from the two surfaces of the bone. The two nerves in no instance pass forwards between the plates of the bone in any part of their extent. At no period during development are the olfactory nerves of the Bird situated mesiad of any part of this bone; for it is originally a mesial cartilaginous plate, a portion of the axis of the primordial cranium, extending forwards and upwards from that part of the primordial axis which, when ossified, constitutes the anterior or acuminated extremity of the centrum of the post-sphenoidal sclerotome. In the sequel, I shall have to point out that this bone in the Bird, which anatomists have hitherto looked upon as the "ethmoid," is, in fact, the body or centrum of the pre-sphenoidal sclerotome converted into a mesial plate extending up to, and flattened out at the upper surface of the cranium, in accordance with the catacentric character of the neural arch of the scleretome, of which it is an element. Its corresponding neurapophyses are the pre-sphenoidal wings,—the "orbito-sphenoids" of Professor Owen,—which not only bound laterally the orifices for the optic, but also those for the olfactory nerves. The so-called "ethmoid" of the Bird is not therefore formed by the coalescence of a pair of "pre-frontals," but is a mesial element belonging to another sclerotome. The Bird already possesses distinct or "divided" "pre-frontals," with all the characters of the "pre-frontals" of the Reptile in its so-called "nasals."

Dugès considered the "os en ceinture" of the Frog to be the ethmoid, from its giving passage to the olfactory nerves by two funnel-shaped orifices at its anterior extremity, and from its intimate connection with the nasal cartilage in front. Professor Owen, on the same grounds, while he holds the posterior part of this bone in the *Rana boans* to consist of the "orbito-sphenoids," looks upon its anterior part as the confluent "pre-frontals." But as the "os en ceinture" of the common Frog originates in a centre of ossification on each side of its fundamental portion of the primordial cranium; and as Professor Owen does not state the grounds on which he holds the "orbito-sphenoids" to be confluent with it in the Bull Frog; as I can find no trace of such confluence, either in the Bull Frog or common Frog; and as the forepart of the bone is divided by a mesial septum,—I look upon it as consisting of a single pair of neurapophyses and a catacentric septum. As this "os en ceinture" is situated upon the upper surface of the anterior acuminated portion of the centrum of the post-sphenoid, as in the Bird; and as it is covered above, and, in the common Frog, is united with the anterior portion of the so-called "parieto-frontal," it appears to me to constitute the neural arch and centrum of the pre-sphenoidal sclerotome, of which the orbito-sphenoids are the neurapophyses. The proper "os en ceinture" of Cuvier is in fact the homologous structure in the aneurous Batrachian with the so-called "ethmoid," and the orbito-sphenoids collectively in the Bird; the centrum being principally developed in the latter, the neurapophyseal elements in the former. On these grounds, and also because I hold, with Cuvier, the "nasals" of the Frog to be its "pre-frontals," I cannot assent to Professor Owen's doctrine, that the "os en ceinture" exhibits a stage in the mesial coalescence of a pair of "pre-frontals," the final effect of which is the formation of a mesial ethmoidal plate, or mesially united nasal neurapophyses.

On the Actinapophyses of the Ethmoidal Sclerotome.—As the radiating elements of the ethmoidal segment of the skull are numerous and important; and as their elucidation requires a more extended reference to corresponding elements in the succeeding sclerotomes than can be made before the examination of these has been entered upon, I shall at present make only a general statement on the subject.

In the Mammal we find a series of sclerous elements arranged from above downwards on each side of the ethmoidal sclerotome. On its upper or neural portion are the olfactory "capsule" and the lachrymal bone. On the lower or hæmal portion the cartilages of the eyelids, with the inferior turbinated and malar bones. If the secondary antero-posterior elongation of the maxillary be kept out of view; and if it be conceived in its fundamental developmentary form as a rib-like bone, the convexity of which is inclined outwards and backwards; and if, at the same time, the possibility of a double arrangement of actinapophyseal elements in each sclerotome be borne in view, it will be seen that the malar extends outwards and backwards from the anterior or outer; the inferior turbinal from the posterior or inner aspect of the bone. I have already stated that the actinapophyseal elements of the cranium are generally flattened or extended so as to abut against one another, and against the other bones of the skull. Thus the malar passes backwards in the fibrous membrane which extends across the orbital opening, and which covers in the temporal fossa. The final purpose of the malar is to afford an abutment against the squamosal so as to strengthen the flank of the Mammalian head. The malar, therefore, in many instances sends secondary processes upwards and inwards, to abut against other bones. While I gladly avail myself of Professor Owen's term "squamosal," and fully agree with him as to the bone itself being a "radiating" element of the cranium; and while I more particularly assent to his very beautiful determination of it as the "quadrate jugal" of the Bird, I must, nevertheless, contend for the much greater probability of its being a radiating element of the mandibular than of the maxillary arch. Its intimate connection with the quadrate bone in the development of the chick, and the disunion of it and the malar in certain Mammalia, appear to me to indicate that they belong to distinct sclerotomes.

The extended attachment from above downwards of the inferior turbinal to the inner aspect of the maxillary of the fœtal Ruminant, a form of attachment which is repeated in the lachrymal process of the bone in the human subject, indicate the primary actinapophyseal form of the bone. Its elongation backwards on the inner aspect of the palate bone, and its prolongation forward to abut against the cartilaginous actinapophysis of the vomerine hæmal arch, are secondary processes in the development of the bone, and steps towards the completion of that antero-posterior system of serially homologous actinapophyses which constitute what may be termed the inferior turbinal system. The inferior concha is peculiar to the nasal fossa of the Mammal. The sclerous elements, which constitute its skeleton in its most fully developed form, are posterior or inner actinapophyses of the rhinal, vomerine, and ethmoidal hæmal arches. These actinapophyses become included in the nasal fossa by the closure of the metasomatomic clefts; and, as they subsequently elongate, they abut against one another in the antero-posterior direction.

I shall, in the sequel, show that the more or less defined space termed orbit, at the side of the Mammalian cranium, is fundamentally the metasomatomic fissure between the ethmoidal and pre-sphenoidal sclerotomes. The upper part of this fissure continues permanently open as the lachrymal canal, and drains away the secretion which bathes the front of the eyeball, while that organ, supported by the sclerotic, which is a presphenoidal neuractinapophysis, and surrounded by its accessory structures, is lodged in its dilated portion. From the upper, anterior, and lower orbital margins, which are formed by elements of the anterior of its two bounding primary sclerotomes, a fibrous membrane extends backwards, covered externally by the orbicular muscle, and closing in the contents of the orbit, with the exception of the front of the eye, exposed through the palpebral fissure. This fibrous membrane is a metasomatomic or actinal lamina, extending very obliquely outwards and backwards, like an operculum over the orbit. The succeeding metasomatomic membrane assumes the form of the tissue which separates the orbit from the temporal fossa, and which, passing backwards external to that fossa, forms the temporal fascia, which constitutes an operculum to that space. The temporal fossa itself is the upper portion of the metasomatomic fissure, between the pre- and post-sphenoidal sclerotomes; occupied by the muscles of mastication and the homologous nerve; the lower part of the fissure on each side remaining permanently open as the mouth, or more correctly as the anterior opening of the isthmus of the fauces. By the extension of ossification from neighbouring bones into the anterior and external portion of this fibrous layer, the orbit may be more or less shut off from the temporal fossa.

The cartilaginous laminæ which support the eyelids of the Mammal are developed in the fibrous layer which constitutes the operculum of the orbit, and lie in the same morphological plane as the malar and lachrymal bones. Their histological as well as morphological relations appear to me to indicate, not only that the palpebral cartilages are actinal elements of the endo-sclerome, but also that they are anterior or external hæm-actinapophyses of the ethmoidal sclerotome. This view of the morphological relations of the malar bone, palpebral cartilages, and opercular membrane of the orbit in the Mammal, is borne out by the corresponding arrangement in the Bird. A fibrous membrane extends backwards over the orbit, from the posterior extremity of the feebly developed maxillary, and from the posterior margin of the descending process of the ethmoido-frontal. In the lower part of this membrane the malar is imbedded; across its centre the palpebral cartilage; and at the antero-superior angle of the orbit, the lachrymal bone. These have all distinct actinapophyseal characters, which, in the case of the lachrymal, enables us to perceive more clearly how the Mammalian lachrymal, having become intercalated between its corresponding hæmapophysis and neurapophysis, retains only so much of its actinapophyseal character as is indicated in the anterior margin of its groove, the remainder of the bone being a secondary expansion.

The lachrymal bone of the Bird may extend into the orbital membrane along the outer margin of the so-called "principal frontal," or sphenoido-frontal, and become attached to that bone without losing its connection with the ethmoido-frontal. It may thus also form a union with the supra-orbital bone, when that bone is present, as in the Hawks. The lachrymal may, moreover, extend backwards under the eye to the post-frontal process, and may have a branch of communication with the antero-inferior projection of the mastoid, as in certain Parrots. It may also extend down to the malar, and may be connected in this direction with the transverse projection of the so-called "ethmoid," or presphenoidal centrum. The infra-ocular bony arch in the Maccaws and certain other Birds is not a zygomatic arch, although consisting like it of actinapophyseal elements. The proper zygomatic arch, as consisting of the malar and squamosal, exists in all Birds; the infra-ocular arch is ossified in comparatively few.

The reference of the lachrymal and the other bony formations round the orbit in Birds to a muco-dermal system by the continental anatomists and by Professor Owen, appears to me to be disproved by their relation to the soft parts. They are all developed in aponeurotic bands, which enter into the formation of the orbital fascia already alluded to. In a band extending along the margin of the sphenoido-frontal, the supra-orbital bone takes its rise, which may thus become connected with the lachrymal, when that bone, which is developed in the anterior extremity of the band, extends backwards in it. A second band extends downwards and backwards from the lachrymal to the malar, forming a ligament between the two bones, and along which ossification may extend. A third band extends from the post-frontal process downwards and forwards to the quadrate-jugal or squamosal, along which ossification may extend from above. In all birds a band connects the lachrymo-malar with the post-fronto-squamosal band, thus forming an arch below the under eyelid. The extension of ossification into this commissural band, probably from both extremities, completes the infra-orbital bony arch, and may approximate or unite it to the squamoso-jugal or proper zygomatic arch. A fibrous band, which extends downwards and forwards in the temporal fascia from the anterior process of the mastoid, becomes ossified in some Birds; and it is an extension of this ossification which appears to form the mastoidal limb, or attachment of the infra-ocular arch of the Maccaw. I shall, in the sequel, state the grounds on which I regard as actinapophyseal all the bones developed in the opercular membrane of the orbital of the Bird. I regard the lachrymal bone and the supra-orbital bone or bones of the Saurians, as referable to the same morphological category; and as due to arrangements in the fibrous operculum of the orbit, similar to those in the Bird; as also the connection between the malar and the post-frontal of the Crocodilian, as well as the change in the direction of the jugal, and the peculiar position of the squamosal in the typical Lizards.

The supra-orbital bone or cartilage, with the infra-ocular bony arch, appear in various forms in the osseous Fish; and the arrangements presented by this form of cranium clearly indicate that these orbital bones are parts of a system of actinapophyseal elements referable respectively to the ethmoidal, pre- and post-sphenoidal, temporal, and occipital sclerotomes, peculiarly modified and connected in front for the protection of the orbit, and behind for the suspension of the pectoral girdle.

THE PRE-SPHENOIDAL SCLEROTOME.—*Its Centrum and Neural Arch.*—It has been already stated that this sclerotome is peculiar in the Mammal, in the absence of its meta-neurapophyses, while this mesial element is more or less fully and largely developed in the other forms of vertebrata. When the cerebrum proper is developed, the sphenoido-frontal bone is absent; when the cerebrum proper is a mere film, as in Birds and Reptiles, or is absent altogether, the sphenoido-frontal is present. As the evidence on which this statement is based is derived from the consideration of the varied relations of all the primary elements in the different forms of cranium, I am compelled, in this preliminary abstract, to refer those who are desirous of weighing that evidence to what has been already adduced with regard to the ethmoido-frontals, and to the statements to be afterwards made in regard to the meta-neurapophyses of the post-sphenoidal and temporal sclerotomes. In the meantime, I shall confine myself to a general exposition of the arrangement as I regard it.

The anterior part of the body of the human sphenoid, and the corresponding pre-sphenoidal piece in the Mammalia generally, constitutes an undoubted centrum, to which the lesser, anterior, or orbito-sphenoidal wings, are the corresponding neurapophyses.

How far we may be entitled to assume the frequent "triquetral" bones in the coronal suture in the human, and in certain other Mammalian crania, and the separately developed antlers of the giraffe, as indications of the missing bone, remains to be determined. I would only observe at present, that the great extent and permanency of the anterior fontanelle appear to be connected with the deficiency in question.

I have already stated that I regard the so-called "principal frontal" of the Bird as the missing frontal of the Mammal. Distinguishing it as sphenoido-frontal, it is the divided meta-neurapophysis corresponding to the feebly developed "orbito-sphenoids," which, bounding the optic and olfactory orifices, constitute the neurapophyses, and to the so-called "ethmoid" as the centrum of the pre-sphenoidal sclerotome. Assuming for the present the signification I have attached to the "principal frontals," and holding the neurapophyseal character of the orbito-sphenoids as incontestable, I would only add a few remarks regarding the central element. The determination of the "ethmoid" of the Birds as the centrum of the pre-sphenoidal segment of the cranium, while it does not require Professor Owen's hypothesis of connation of this element with the centrum behind, presents the element under a form similar to that exhibited by the ethmoidal and vomerine centrums. It resembles these in being an ossified portion of the primordial axis of the cranium, in being flattened into a horizontal plate at its upper margin, in extending down to the line of the base of the skull, and in thus presenting a catacentric relation to its neural arch. The passage of the anterior acuminated extremity of the centrum behind beneath the lower margin of the pre-sphenoidal centrum, so as to support it, is merely an example of that longitudinal obliquity in the setting of cranial centrums against one another, which may be considered as the rule rather than an exception. The posterior margin of the bone is oblique from below upwards and forwards; gives attachment to the orbito-sphenoids, or to their membranous neurapophyseal substitutes, which bound or give passage to the orbital and olfactory nerves. The obliquity of this margin of the bone corresponds with the similar obliquity of the forepart of the basis of the brain of the Bird, a remarkable feature in its configuration. The flattened upper edge of the bone may be more or less exposed on the upper surface of the cranium; and when the intermaxillaries, ethmoido and sphenoido-frontals are removed, this flattened margin is found to be similar to and continuous with the flattened upper margin of the ethmoidal and vomerine cartilaginous septum. The anterior margin may be nearly perpendicular, but is generally oblique from below upwards and forwards, concave or concavo-convex, sharp, and generally free, being connected to the posterior margin of the ethmoidal cartilaginous septum by membrane, thus permitting more or less movement of the upper mandible, that is of the combined ethmoidal and vomerine sclerotomes on the pre-sphenoidal.

In the majority of Birds a laminar process projects outwards and downwards from the lower and forepart of this bone. This process, variously developed, forms, along with the descending process of the lachrymal, the anterior wall of the orbit, separating it from the nasal space, and permitting the passage of the olfactory nerve through a notch or hole in its upper edge. I regard this process on each side of the pre-sphenoidal centrum as of the same nature as the process which will be found projecting from each side of the lower part of the ethmoidal septum or centrum, and which, abutting against the descending process of the ethmoido-frontal, forms a wall or rampart across the floor of the nasal passage, extending nearly half way up to its roof, immediately behind the external nostril, thus converting that part of the nasal chamber in front of it into a vestibule. This process is largely developed in the ossified ethmoido-vomerine septum of the Hawks and Owls.

I would here observe, that the "os en forme de cuiller" of Cuvier, which he considers as the inferior turbinal of the Lizard, and which forms the forepart of the floor of the nostril on each side, and the convex anterior part of which stretches like a buttress across the cavity, between the septum and the maxillary, immediately behind the external nostril, appears to me to be, with its fellow of the opposite side, merely the ossified lower portion of the ethmoidal centrum. These so-called "cornets inferieurs" of the Lizard form the floor, and do not, therefore, project from the outer wall of the nasal passage in the manner of the inferior turbinals; and I believe anatomists will, in reviewing the subject, admit that the inferior turbinal accompanies the fully completed maxillary arch, and only exists, therefore, in the Mammal.

I regard these lateral processes of the ethmoidal and pre-sphenoidal centrums of the Bird as homologous with the pterygoid processes of the post-sphenoidal centrum, and generally with those processes which, under various forms, project downwards from the sides of the lower or hæmal aspects of the occipital and succeeding centrums in certain Fish, or with those processes termed "hypopophyses" by Professor Owen.

Before dismissing the consideration of this important centrum in the Bird, I would direct attention to certain interesting modifications which it may undergo. In the first place, it may, like many other bones in the cranium of the Bird, become greatly dilated and altered in form by the development of air-cells in its interior. The pneumatic openings are two in number, one on each side of the anterior margin below the superior horizontal plate. The pneumatic excavation and dilatation extends backwards more or less in certain species; and in some Owls the bone presents the form of a cubical cellular mass. This peculiarity of form might be adduced in support of Professor Owen's doctrine of the formation of this bone from the coalescence of the pre-frontals; but then it will be observed that the increased breadth of the bone is not due to incomplete mesial fusion of lateral parts, but to expansion from the mesial plane, for the olfactory nerves still run forwards in grooves on its lateral aspects, although these may be deep in front, and, posteriorly, their margins may overlap the nerves. The expansion of the pre-sphenoidal centrum also produces a remarkable separation of the optic foramina. As explanatory of this effect, I would observe, that the development of this bone in the Chick shows that it forms the posterior border of the common optic foramen by means of a pair of processes which project from its posterior inferior angle like the limbs of the letter Y. When, therefore, the bone takes on transverse dimension, the single optic chasm separates into two optic foramina, which, in *Strix flammea*, are three-eighths of an inch asunder.

The separation of the optic foramina from the pneumatic expansion of the pre-sphenoidal centrum leads me, in the second place, to observe, that the characteristic separation of these orifices in the extinct forms Dido, Dinornis, Palapteryx, did not depend entirely on pneumatic expansion of the pre-sphenoidal centrum, nor on such width of that bone as might be attributed to incomplete mesial fusion of a pair of "pre-frontals," but on the remarkable prolongation backwards on each of its sides of the neurapophyseal walls of the ethmoidal olfactory chambers.

Professor Owen, in his series of graphic and valuable memoirs on these three extinct forms, and in his memoirs on Apteryx, assuming the pre-frontal doctrine regarding the bone in question, and directing special attention to the more or less complete passage backwards of the nasal chambers to the anterior or inferior wall of the cranial cavity, and to the passage of the olfactory nerves into these by a number of orifices, apparently recognises in Apteryx for instance (although he does not directly make the statement), a completed Mammalian ethmoid. Now, recalling attention again to the embryological considerations from which the formation of neither the Mammalian ethmoidal septum, nor the so-called ethmoid of the Ostrich, Dinornis, Dodo, nor Apteryx, can be conceived as resulting from coalesced pre-frontals, I would remark, that the arrangement of the nasal fossæ in Apteryx, instead of being Mammalian, presents the peculiar Ornithic character of its parts, fully brought out; all the phases in the development of which may be observed in the series of Birds. In all Birds, the posterior extremities of the cartilaginous pouch-like ethmoido-neural, or olfactory chambers, approach or encroach upon the sides of the pre-sphenoidal centrum; so that the membrane which connects its anterior margin to the cartilaginous nasal septum, and a certain extent of both its surfaces, separate the two pouches from one another. The laminar or hypopophyseal process on each side of the bone, variously modified in form, limits, posteriorly and inferiorly, the olfactory portion of the lateral surface of the bone, and, folded over the pouch, walls it in more or less from below; while the lachrymal from above passes down on its outer side. The gradual environment of the pouch may be traced in the series of Birds; and I find in the Asiatic Cassowary, the stage immediately preceding the completion of the process in Apteryx. In this Bird, the pair of deep fossæ in the interior of the skull, which lodge the olfactory lobes, are separated from one another by the posterior margin of the pre-sphenoidal centrum, which here represents the crista-galli. The plate of bone which forms the floor of each fossa, instead of being cribriform as in Apteryx, is perforated by a single star-like foramen, a form due to the partial shooting across of bony processes from its margin.

In the Chelonian.—The neural arch and centrum of the Chelonian are represented in the dry skull by the pair of bones usually considered as the "proper frontals," but which I regard as sphenoido-frontals. In the recent condition the centrum appears in the form of a compressed cartilaginous bar, continuous posteriorly with the compressed anterior part of the post-sphenoidal centrum, resting below on the conjoined pterygoids and ento-pterygoids, continuous in front with the cartilaginous ethmoidal septum or centrum, and thus presenting all the relations of the pre-sphenoidal centrum of the Bird. It is continued upwards, and represents the orbito-sphenoids, or neurapophyses, in the form of a double fibro-cartilaginous membrane, the two laminæ of which separate to unite with the posterior margins of the orbito-nasal processes of the ethmoido-frontals, with the two parallel descending ridges of the sphenoido-frontals, and with the anterior margins of the peculiar descending processes of the so-called "parietals." The olfactory nerves pass forwards between these neurapophyseal laminæ above; and the optic with the other orbital nerves perforate them.

In the Crocodilian.—In the Crocodiles, the sphenoido-frontals have coalesced; but the cartilaginous centrum, and neurapophyseal interorbital laminæ, present exactly the same relations as in the Chelonian; the only difference being the result of the union of the orbito-nasal processes of the sphenoido-frontals near their lower extremities, and the consequent space left between this bony bridge, and the deep furrow formed by the inclined upper surfaces of the ento-pterygoideal portions of the pterygoids.

In the Lacertians.—In the Lizards, the sphenoido-frontal is again double. In consequence of the mesial separation of the ento-pterygoids ("palatals") and pterygoids, the elongated fibro-cartilaginous centrum and neurapophyseal interorbital laminæ, are left unsupported below; to which circumstance is probably due the formation in the inter-orbital laminæ, of a pair of delicate triradial osseous neurapophyses, which pass off from the upper margins of the optic foramina.

In the Ophidian and Batrachian.—Leaving the further consideration of the special homology of the anterior sphenoidal wing in the Reptiles, and more especially in the Crocodiles, until the posterior sphenoidal wing, and the so-called "petrosal," have been examined, I would observe, that the grounds on which Professor Owen distinguishes the "os en ceinture" of the Frog, from that segment in the Python which includes the so-called "frontals," appear to me somewhat arbitrary. This segment in the Serpent consists of a pair of neurapophyses, or orbito-sphenoids, which are distinct, as cartilages at least, in the embryo; of a double meta-neurapophysis (sphenoido-frontals), which not only occupy on each side the positions of the neurapophyses, but extend the forepart of their inner margins downwards, back to back, in the mesial plane, on the sides of the compressed centrum; which thus, along with them, divides the neural chamber in front, for the transmission of the olfactory nerves. The sides of the "os en ceinture" are formed by neurapophyses; while the so-called "frontals" of the Serpent occupy the greater part at least of the sides of their segment; in other respects, their relations are similar. They are both catacentric; the centrum, in both, resting, as in the Bird, on the upper surface of the anterior acuminated extremity of the post-sphenoidal centrum, and in the plane of the ethmoidal centrum in front. I regard, therefore, the "os en ceinture" in the Batrachian, along with the anterior segments of its "parieto-frontals," as consisting of the centrum,

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neurapophyses, and meta-neurapophyses of the pre-sphenoidal sclerotome; and, therefore, also as homologous with that segment in the Ophidian which includes its "frontals," but exclusive of the elongated anterior prolongation of the post-sphenoidal centrum.

The Pre-Sphenoidal Centrum and Neural Arch in the Fish.—The bone which predominates over every other in the cranium of the Fish is the so-called "principal frontal"; which, however, as already stated, I do not regard as the frontal or ethmoido-frontal of the Mammal, but as a sphenoido-frontal. It is the pre-sphenoidal meta-neurapophysis of the Fish, presenting all the relations of the corresponding bone or bones in the Bird, Chelonian, and Lizard, except that the ethmoido-frontals anterior to it have coalesced in the middle line; while the ethmoidal neurapophyses have become so much developed, exposed, and connected to it laterally, as to assume the position of the so-called "nasals" and pre-frontals" in the Bird and Reptile. The enormous development of this bone in the Fish and Bird appears to depend on the great bulk of the organs of vision. There is, therefore, in both, an extended inter-orbital space to be filled up. In the Fish, as in the Bird, this is variously effected by means of fibro-cartilage and bone. The extreme forms of the inter-orbital arrangement may be illustrated by the Gadoid and Cyprinoid Fishes. In the Cod the greater part of the so-called inter-orbital septum consists, as in the Chelonian and Lizard, of a double fibrous membrane, which extends upwards from the anterior prolongation of the post-sphenoidal centrum to the margins of the mesial grooves on the under surface of the sphenoido-frontal. The two laminæ of this membrane thus bound the sides of the compressed neural space, along the upper part of which the olfactory nerves pass forward. In the posterior superior part of each of these neurapophyseal fibrous laminæ, a comparatively small plate of bone is developed, while the centrum consists of the bar of persistent cartilage, which extends along the grooved upper surface of the anterior portion of the post-sphenoidal centrum, and terminates above the ethmoidal centrum ("vomer"). The optic nerves pierce the membranes so far back as to notch very deeply the anterior margins of the post-sphenoidal neurapophyses, or post-sphenoidal wings.

In the Carp, again, the inter-orbital space is occupied above by a considerable descent of the margins of the sphenoido-frontal groove; in front, by complete ossification of the fibrous membranes, which thus become pre-sphenoidal neurapophyses; behind, by the passage forwards of the post-sphenoidal wings ("ali-sphenoids"), through which, during development, the optic nerves have passed back, to be lodged in notches in their posterior margins; and below, by the bar of semi-ossified cartilage situated upon the upper surfaces of the posterior sphenoidal and ethmoidal centrums.

Of the Hæmal Arch and Hænnactinapophyses of the Pre-sphenoidal Sclerotome.—The palatine arch, between which and the mandibular the mouth is situated, and which terminates therefore posteriorly the prestomal series of hæmal arches, may be presumed to undergo very varied modifications in connection with the olfactory, the respiratory, and the digestive functions. In the present instance, as in many others, the anatomy of the human body, instead of leading astray by complexity and extreme modification of its parts, supplies the key for their morphological solution by affording an example of the employment of the fundamental type of structure for the fulfilment of the most complex functional purposes.

The human pre-sphenoidal centrum, hollowed out by nasal air-cells, as in certain Birds, is bounded below and in front by a pair of separate triangular-curved bony plates, which, limiting the size of the right and left pneumatic orifices, bring these into communication with the posterior ethmoidal air-cells or sinuses. These "sphenoidal turbinated bones," or "bones of Bertin," in contact along their outer margins, and outer part of their inferior aspects, with the sphenoidal processes of the palate bones, constitute the upper elements or suspensory extremities of the inverted arch, completed by the meeting of the palate bones themselves in the posterior part of the mesial line of the palatal vault. The right and left pterygoids are attached, as a pair of actinapophyses, to this arch. They pass off backwards and outwards from the posterior margins of the perpendicular plates of the palate bones, and abut in the embryo against the upper and fore part of the mandibular arch, retaining in the tympanic processes of their adult form, indications of their early connection with that arch. The most important secondary connection of the pterygoids in the human adult is with the pterygoid processes of the post-sphenoid; and it is this sphenoidal connection which is most frequently repeated in the animal series.

I shall not enter at present into the question of the probable existence of "bones of Bertin" in the Mammalia generally; nor enquire whether the separate orbital pieces of the palate bones in the herbivorous Cetacea, according to Cuvier, and the separate anterior portions of the pterygoids of the young Dolphin, as described by Meckel and Rapp, may be indications of the upper elements of the palatal arch; but pass on to the consideration of the palatal arch in the lower Vertebrata, in which the two elements of which it appears to consist on each side, are distinctly developed.

The Palatal Arch and Pterygoids in the Bird.—The bone hitherto considered by all anatomists as the vomer of the Bird, is a more or less elongated narrow plate, the margins of which are bent upwards so as to convert its upper surface into a groove, which is applied against the under surface of the acuminated anterior extremity of the post-sphenoidal centrum, which is therefore interposed between it and the pre-sphenoidal centrum. This bone, more or less compressed or extended laterally, separates the posterior nostrils from one another. Its anterior extremity reaches the anterior limits of these orifices, or, passing forwards into the palate between the ethmoidal neurapophyseal and maxillary palatal laminæ, and concealed more or less by them, may terminate on the surface of the palate between the intermaxillary palatal plates. When this bone is much compressed it is single throughout; when flattened, it is more or less extensively divided in the mesial line.

The palate bones of the Bird, more or less elongated, extend anteriorly under the maxillary palatal laminæ, to which in general they are only slightly connected, forward to the intermaxillary palate plates, with which they are anchylosed or articulated, separated from one another in front, to form the lateral boundaries of the posterior nares, the palate bones become broader posteriorly, approach one another, and are either attached to, or anchylosed with, the posterior extremity of the so-called "vomer." Their posterior extremities are provided with facets for articulation with the bar-like pterygoids, which extend from them, outwards and backwards, to articulate with the quadrate bone on each side. The pterygoids of certain Birds have also secondary connections; they articulate with processes which project from the post-sphenoidal centrum in some part of its extent; and on which their shafts glide, rotate, or vibrate.

The reciprocal relations of the so-called "vomer," the palatines, and pterygoids of the Bird, are extremely interesting and important. At present, I can only direct attention to those relations which bear upon my subject. When the palate bones are greatly developed, the "vomer" diminishes. When, again, the "vomer" is much developed, the palatines are in an atrophied condition. The pterygoids present phases of development dependent on the variations of the palatines and pterygoids. The two extremes may be observed in the Parrots and the Struthious Birds. In the former, the palatines are enormously developed, while the "vomer" has disappeared. In the latter, the "vomer" is greatly elongated and developed, while the palatines present the relation, and exhibit the form of the "transverse" or "adgustal" bones of the Reptile.

The Palatal Arch and the Pterygoids in Reptiles and Amphibians.—The three bones on each side, which form the palatal system of the ordinary Lizard, present the same relations, and almost the same form as the "vomer," palatines, and pterygoids of the Struthious Bird. The pterygoids are in every respect similar. The "transverse bones" of the Lizard are also, in relations and almost in form, like the palatines of these Birds. The so-called "palatals" of the Lizard, while they exhibit all those relations to the "transverse" and pterygoids, which the "vomer" of the bird presents, differ from that double bone in this respect, that although in contact at the mesial line, they are comparatively so much broader, occupying so much of the comparatively narrow palatal space that they touch the maxillaries by their anterior external angles. They bound, therefore, the internal nares posteriorly; but like the so-called vomer in the Bird, separate them from one another, passing forward like that double bone to the ethmoidal neurapophyseal plates, which constitute the so-called "vomer" of the Lizard. In the monitors, these so-called "palatines," like the pterygoids, are evidently separated in the middle line, and forced backwards along the inner margin of the maxillary towards the transverse bones, by the development and elongation of the ethmoidal neurapophyseal elements. In the Crocodiles, again, the full development of maxillary palatal plates, and more especially of the ethmoidal neurapophyses, has forced backwards and towards the middle line, not only the bone called "palatal" in the Lizard, but also the pterygoids; and as the latter also exhibit that remarkable tubular development, various phases of which are perceptible in the Chelonians, Birds, and Mammalia, the former again presents the ornithic vomerine aspect.

In the Ophidia the two halves of the palatal system are widely separated at the middle line. The so-called "palatals," elongated forwards into the ethmoidal region, articulated by ascending processes to the presphenoid, slightly attached externally to the maxillaries, as in the Lizards, bound as in these Reptiles, the nostrils posteriorly, but do not separate them mesially.

In the Frog, the so-called "palatals" extend transversely outwards from the "os en ceinture" to the maxillaries, being also connected at their outer extremities with the pterygoids. The latter are articulated posteriorly to the post-sphenoid and to the quadrate bone. The "os transversum" has disappeared at the junction of the so-called palatal, pterygoid, and maxillary.

The modifications presented by these bones in Reptiles and Amphibia are much too numerous to be followed in detail at present. I have, therefore, selected those which are essential for the elucidation of my subject; and shall sum up the conclusions I draw from them, by a comparison of them with the corresponding elements in Chelonians.

The Chelonians, we are told, have no "transverse bone." They are distinguished in this respect from all the other Reptiles. But if we examine the skull of a Tortoise, we shall find all the elements which enter into the formation of the palatine aspect in that of the Crocodile. In front are the intermaxillaries, immediately behind which, in the median line, is the double bony plate, which is usually described and figured as the forepart of the so-called "vomer," but to which I have already directed attention as the combined ethmoidal neurapophyseal elements. In the Turtles the maxillaries meet across the palatal vault in front of the united ethmoidal neurapophyses, so that the latter are pushed backwards, and are in contact laterally with the palatals in the vault of the palate; while in the Tortoise the latter want entirely the palatal processes, consisting, as Cuvier expressed it, only of their upper portions, and extending outwards on each side from the outer margins of the so-called "vomer," and of the pterygoids, to the inner margins of maxillaries. Now, let the base of the skull of a Tortoise, a Turtle, and a Crocodile, be examined side by side. In all three we shall find the intermaxillaries in front. The maxillaries, although they do not meet across the palate of the Tortoise, do so in that of the Turtle, and thus, as in the Crocodile, bound posteriorly the intermaxillary segment of the palate. The transverse union of the maxillaries in the Turtle and Crocodile, pushes back the ethmoidal neurapophyses (which are in contact with the intermaxillaries in the Tortoise), but to such an extent in the Crocodile that the ethmoidal neurapophyses, also themselves much elongated, carry back the pterygoids, so that the latter almost entirely conceal the post-sphenoidal centrum. The outer margins of the pterygoids, already curved downwards in the Tortoise and Turtle, pass downwards and inwards in the Crocodile, so as to meet again in the mesial line of the palatal vault. The bony septum of the pterygo-ethmoidal portion of the nostrils of the Crocodile is at the same time seen to be the result of the extension downwards in the mesial plane of the middle ridge of the so-called "vomer" of the Tortoise or Turtle, and of the connection of the anterior part of that double bone with the ethmoidal neurapophyses. It will thus be observed, that if the maxillaries of the Tortoise were united across the palate, in front of its ethmoidal neurapophyses, to a considerable extent backwards; if the ethmoidal neurapophyses were also elongated in the same direction; and if the outer margins of the pterygoids, below the palatines, were to meet in the mesial line, the latter would be forced backwards and outwards; so that, still retaining their connections with the pterygoids and maxillaries, but leaving those with the "vomer" in front and internally, to abut against the malar behind and externally—the palatal aspect of the skull of the Tortoise would present the arrangement of the corresponding region in that of the Crocodile, the palate bones assuming the form and relations of "transverse bones."

If to the skulls of the Tortoise, Turtle, and Crocodile, those of a Serpent, a Lizard, a Frog, and an Ostrich be added, it will be observed, that the palate bones have disappeared in the Frog; that they have assumed the form and relations of "transverse bones" in the Lizard, Crocodile, and Serpent; that they are essentially "transverse bones" in the Struthious Bird, while in the Tortoise, but especially in the Turtle, they present the Mammalian character and form. It will also be observed, that the bones in the Turtle, Tortoise, Crocodile, and Bird, hitherto denominated "vomer," are the same bones which in the Frog, Lizard, and Serpent are named "palatals," the term "vomer" being applied in these animals to those two bones collectively, which are situated under the ethmoidal portion of the skull. It will also be noted that the bones called "vomer" in the Turtle, Tortoise, Crocodile, and Bird, and the bones called "palatals" in the Frog, Lizard, and Serpent, are related to the others, along with which they have been examined, exactly as the "bones of Bertin," in the human cranium, are to the palate bones and pterygoids.

The Pre-sphenoidal Hæmal Arch and Hæmactinapophysis of the

Fish.—In the osseous Fish a fibrous membrane extends outwards and downwards on each side from the suborbital bar-like portion of the basis of the cranium. In most Fishes there will be found in this membrane, where it passes off from the pre-sphenoidal portion of the cranium, a more or less elongated scale-like bone on each side. This is the "ptérygoïdien interne" of Cuvier, the "hérisséal" of St Hilaire, the "ento-pterygoid" of Professor Owen. The palate bone, connected by the same fibrous membrane to the outer margin of the ento-pterygoid, extends forwards to the side of the so-called "vomer," or to the ethmoidal centrum and neurapophysis, to which, as also to the maxillary and intermaxillary, it is variously attached directly and indirectly. The corresponding actinapophyseal element or pterygoid in the Fish is firmly connected in front to the palate bone, and less intimately to the ento-pterygoid, and, extending backwards, downwards, and outwards, abuts against the anterior margin of the "hypotympanic" and "pre-tympanic" bones, as the pterygoid of the Bird and Reptile does against the so-called "quadrate," or "tympanic" bone. If, then, the basal aspect of the cranium of the osseous Fish is placed in series with those of the Bird, Lizard, Serpent, Tortoise, and Frog, it will be observed, that while its palatals and pterygoids may be at once associated with the corresponding bones, as already determined, in the Bird and Reptile, the ento-pterygoid of the Fish presents all the relation of the double bone, usually called "vomer" in the Bird; of the posterior or horizontal portion of the bone called "vomer" in the Tortoise; and of the bones called "palatals" in the Lizard, Serpent, and Frog. It will also be observed, that while the toothed bone, called "vomer" in the Fish, has, from a cataeentric change, disappeared from the under aspect of the cranium in the Bird, Reptile, and Batrachian, the two bones, called in the Fish "pre-frontals"—its ethmoidal neurapophyses—present the same relations to its ento-pterygoids as the ethmoidal neurapophyses of the Bird to its so-called "vomer," and as those of the Tortoise to the posterior portion of its so-called "vomer," and as those of the Lizard, Serpent, and Frog to the bones hitherto called "palatal" in these three forms. I therefore apply provisionally the term ento-pterygoid to the so-called "vomer" of the Bird, to the posterior part of the so-called "vomer" of the Chelonian, to the corresponding bony piece in the Crocodiles, to the so-called "palatals" of the Ophidian, Lacertian, and Batrachian, to the "bones of Bertin," and their representatives in the Mammal.

The constitution of the Nasal Fossæ, and the relative positions of the External and Internal Nares.—The details necessary for the morphological examination of the rhinal, vomerine, ethmoidal, and pre-sphenoidal sclerotomes, have involved a number of facts connected with the varied constitution of the nasal fossæ in the different vertebrate forms. As, however, the constitution of these fossæ has important bearings on the morphology of the entire cranium, I shall briefly direct attention to the subject.

The only perfect form of nasal fossæ is that presented by the Mammal. They consist of the entire neuro-hæmal cavities of the rhinal and vomerine, combined with the hæmal cavities of the ethmoidal and pre-sphenoidal sclerotomes. That portion of the combined nasal fossæ which consists of the cavities of the rhinal and vomerine sclerotomes, is divided in the mesial plane by the centrums of those sclerotomes; while the dependent portion of the ethmoidal centrum, and the posterior portion of the vomerine centrum, divide in the same manner that part of the combined fossæ which consists of the hæmal cavities of the ethmoidal and pre-sphenoidal sclerotomes. The Mammalian nasal fossæ are therefore bounded in front by the walls of the neuro-hæmal chambers of two catacentric sclerotomes;

and, posteriorly, by the catacentrically divided hæmal chambers of a demicatacentric and diacentric sclerotome.

As the hæmal portions of the cephalic somatomes are separated from one another in their early embryo condition by meta-somatomic clefts, we may expect to find traces of these clefts in the walls of the adult nasal fossæ.

The first or anterior pair of meta-somatomic clefts of the embryo head, that is the clefts between the rhinal and intermaxillary lobe of the "median frontal process," are retained in the adult as the external nares. These openings in the non-proboscidian Mammal, are situated therefore between the ali-nasal cartilages and the intermaxillary bones. In the proboscidian Mammals, they are probably situated between the ultimate and penultimate, or, at least, between two of the distal somatomes of the proboscis.

The second pair of meta-somatomic clefts, situated between the external angles of the median frontal process and the lateral frontal processes, may disappear entirely in the course of development; but they occasionally remain under the form of Stenson's ducts, which pass obliquely through the so-called "incisive spaces," or "foramina," from the mouth to the nasal fossæ, between the intermaxillaries and maxillaries. The mucous walls of the canals of Stenson are supported by cartilaginous tubular folds, which are continuous superiorly with cartilaginous laminæ, which, passing off laterally from the lower margin of the nasal septum and vomer, cover more or less of the floor of the nasal fossæ, upper part of the incisive fissures, and spaces between the intermaxillaries and maxillaries. The "organs" or "sacs of Jacobson," supplied by the olfactory and fifth nerves, lined by glandular integument, sheathed by a continuation of the cartilaginous laminæ already alluded to, and opening into the canals of Stenson, when these are present, are, whatever their function may be, morphologically connected with the second pair of meta-somatomic clefts.

The next pair of meta-somatomic clefts, situated between the lateral frontal processes and the so-called "superior maxillary" deflection of the "first visceral lamina," continue pervious in all the Mammalia except the Cetacea. The lachrymal canals which connect the anterior pouches of the conjunctivæ with the nasal fossæ, consist of the persistent upper portions of these clefts. Their outer or lower portions are obliterated, but the corresponding inter-scleratomic space, much dilated, constitutes that part of the orbit formed by elements of the ethmoidal and presphenoidal sclerotomes, while the spheno-palatine and posterior palatine foramina and fissures, are also enclosed portions of the space between these two sclerotomes, retained for the passage of vessels and nerves.

The posterior nares are not meta-somatomic openings, they are merely the communications between the catacentric hæmal space of the presphenoidal, and the corresponding but undivided hæmal spaces of the succeeding somatomes.

The mouth is the persistent and developed form of the great cleft between the pre- and post-sphenoidal somatomes. It is situated therefore morphologically in the same transverse plane as the posterior nares. Its fundamental or morphological relations are retained and represented by the posterior isthmus of the fauces. The buccal chamber is a vestibule superadded to the alimentary tube, by the anterior elongation of the lower jaw, and by the development of the floor of the mouth and of the tongue, with the consequent inclusion of the vault of the palate; so that the latter, instead of forming the anterior portion of the hæmal or sternal aspect of the head, becomes apparently a portion of the wall of the visceral tube.

The complete development of the vomer characteristic, as already stated of the Mammalian head, is also a characteristic feature of the nasal fossæ in the Mammal. As the centrum of that sclerotome, of which the intermaxillaries are the hæmapophyses, it extends back from them to abut against the pre-sphenoidal centrum, forming a beam which adds to the antero-posterior strength of the entire arrangement, and which supports the more feebly developed ethmoidal and rhinal portions of the nasal septum. All these relations of the vomer are retained in the remarkably modified nasal passages and snout in the Cetacea.

The seat of the olfactory sense is limited to the upper part of the ethmoidal portion of the nasal fossæ. However complex the arrangement of the ethmoidal turbinal laminæ may be, they invariably present the general character of folded laminar neuractinapophyses, connected to their corresponding neurapophyses, after the type of the cartilaginous sessile olfactory cups in the Plagiostomes.

As already stated, the so-called inferior turbinals consist of an antero-posteriorly arranged series or system of mutually abutting hæmactinapophyses, enclosed during development within the nasal fossæ. The inferior turbinal system is peculiar to the Mammal, and consists of elements which, in developed forms of the system, are derived from, and attached to, the rhinal, vomerine, and ethmoidal hæmapophyses. The palate bone, or distal pre-sphenoidal hæmapophysis, supports the posterior extremity of the turbinal system, but I have not had occasion to observe any turbinal element supplied by it.

As the rhinal sclerotome has disappeared in the Bird, the neuro-hæmal chambers of the vomerine sclerotome become closed in front, and the external nostrils are supplied by those metasomatomic clefts between the vomerine and ethmoidal sclerotomes, which in the Mammal form the "incisive foramina," the "canals of Stenson," and the "organs of Jacobson."

As the anterior nares are removed one somatome back in the Bird, so the posterior nares are removed one somatome forwards. They are situated between the maxillary and incomplete palatine arches, the ento-pterygoids separating them, while the palatines are on their outer sides. The posterior nares, instead of being directed backwards in a plane at right angles to the axis of the alimentary tube, open downwards in the plane of its upper wall. This direction of the posterior nares is due to the following circumstances:—1. that the intermaxillaries, although completing their arch below, are principally developed upwards and backwards; 2. that the maxillaries, even when they meet partially across the middle line, have the space which they enclose occupied by the neurapophyses, centrum, and sense capsules of their own sclerotome—in other words, they are in contact with the central and neurapophyseal aspect of their own sclerotome; 3. that the palatines do not form an arch at all, but lie in the horizontal plane of the under surfaces of the centrums of the cephalic sclerotomes behind them.

The Bird, in fact, does not possess nasal fossæ in the same sense as the Mammal, that is, it does not present nasal chambers, formed by the completed hæmal arches of a certain number of sclerotomes. Its nasal fossæ consist only of the catacentric-hæmal or neuro-hæmal spaces of the vomerine sclerotome, and of the combined neural and "sense capsule" spaces of the ethmoidal sclerotome, which occupy the space enclosed by its hæmal arch. They differ therefore from the Mammalian nasal fossa, not only in wanting rhinal compartments, but also in the deficiency of ethmoidal and pre-sphenoidal hæmal spaces. The palate of the Bird, instead of being like that of the Mammal, situated in a plane inferior and parallel to that in which the vertebral column lies, is in the plane of the latter, like that of the Fish. The palate of the Fish is in the horizontal plane of the vertebral column, because its nasal fossæ are absent, the constituent hæmal arches being all incomplete; and because the cavities of its olfactory capsules open externally. The palate of the Bird is in the horizontal plane of the vertebral column for reasons already stated, and also because the olfactory capsules, instead of being situated external to the cavities of their sclerotome as in the Fish, or in its hæmal cavity as in the Mammal, have become involved in, or have taken the place of its neural chamber, and have therefore their inner orifices or posterior nares directed downwards, on the central aspect.

The mode in which the walls and cavities of the olfactory capsules of the Bird become involved or lost in its ethmoidal neural chamber and walls, may be morphologically conceived, if the structure is compared with the corresponding segment of the cranium of a Ray. The cranium of the Plagiostome is modelled on the form of the "primordial cranium" of the Mammal and Bird. The laterally projecting sessile cartilaginous olfactory cups communicate each by a wide orifice with the cranial cavity. If the orifices be conceived as much enlarged, and the walls of the capsules as withdrawn into, or becoming continuous with, those of the cranium; or if the latter be conceived as disappearing, while the former take their places, the general arrangement of the ethmoidal section of the persistent "primordial cranium" of the Ray will be seen to be similar to that sclerotome in the Bird's skull, which retains most of the primordial character. The development of the imperfect maxillaries in contact with the lower aspect of the slightly ossified inferior wall of the combined capsular and neural mass, and the formation of the ethmoido-frontals in the perichondrium which covers its upper surface, would reduce the entire arrangement to the type of the corresponding parts in the Bird.

By a similar process, the sessile cartilaginous auditory capsules of the Cyclostome may be conceived to become buried in the temporal portions of the cranial wall in the Plagiostome, while in the osseous Fish, after the primordial cranium has become enveloped in the bony plates which are formed in its substance and in its fibrous covering, the auditory capsules pass into the cranial cavity, having been enclosed by the neurapophyseal and metaneurapophyseal bony pieces of their own and neighbouring sclerotomes.

The external nostrils of the Lacertian, Ophidian, and Amphibian, are situated, as in the Bird, between the vomerine and ethmoidal sclerotomes; the intermaxillaries being closed in front and below. The so-called nasal fossæ in their vertebrate forms are also, as in the Bird, merely olfactory chambers, occupying the neural space of the ethmoidal sclerotome. The posterior nares, too, open as in the Bird, between the ethmoidal and presphenoidal sclerotomes, but with the following subordinate differences:—In the Lizard they are separated by the anterior extremities of the entopterygoids, and are bounded behind by the maxillary processes of these bones, and externally by the maxillaries themselves. In the Ophidian they are separated by the free margin of the ethmoidal catacentric plates; anteriorly by the posterior margins of the ethmoidal neurapophyses, externally by the anterior projecting portions of the ento-pterygoids, and behind by the pre-sphenoidal attachments of the latter. In the Frog they open between the ethmoidal neurapophyses ("vomer"), the ento-pterygoids ("palatals"), and the maxillaries.

We again approach the Mammalian type of nasal fossæ, through the Tortoises, Turtles, and Crocodiles.

It has been already stated that the anterior nostrils of the Chelonian appear to possess more of the Ornithic than Mammalian conformation. The primordial cartilaginous lining of the olfactory fossæ project in some

Turtles through the anterior nasal opening of the cranium in the form of a double proboscis. The posterior nares in the Tortoises are separated by the combined ento-pterygoids (upper and back part of the "vomer") and are bounded by the maxillaries and the palatines, the latter remaining open or ununited across the vault of the palate. In the Turtles, the vault of the palate and the posterior nares present more of the Mammalian aspect, although still formed essentially on the type of the corresponding parts in the Bird. This is effected by the ethmoidal neurapophyseal plates (palatal plate of the "vomer"), which lie somewhat above the level of the vault of the palate in the Tortoises, passing down into, and forming an area of it in the Turtles, extending from its posterior margin half way, or quite up to the intermaxillary palate plates. In the latter arrangement the ethmoidal area is hexagonal, and separates the palatal plates of the maxillaries from one another. In the former it is pentagonal; and the palatal maxillary plates meet in the mesial line in front of it. The palatal plates of the palatines are more or less developed in the Turtles; and many approach one another at the free margin of the vault, but are always separated by the posterior or free margin of the ethmoidal area.

The arrangement of the vault of the palate in the Turtles, and the peculiar Chelonian configuration of the pterygoids, lead to the very remarkable combination of Ornithic and Mammalian structure presented by the nasal fossæ and palatal vault of the Crocodiles. The Mammalian characteristics are the full development of the inter-maxillary and nasal bones, with the extensive, although cartilaginous, vomer. The vomerine sclerotome of the Crocodile is not closed anteriorly as in all the other Lacertians, in the Ophidians, Amphibians, and Birds; but presents a completely perforated catacentric arrangement. This complete form of the vomerine necessitates a rhinal sclerotome, which, accordingly, feebly represented in the Crocodiles and Alligators, appears to be more fully developed in the Gavials. The extensive and complete Crocodilian palatal vault is only apparently Mammalian, it is partially Ornithic or Chelonian in its constitution. As in the Mammal the anterior extremity of the vault is formed by the pair of fully formed palatal inter-maxillary plates. Except in the Alligators in which there is a slight intrusion of the ento-pterygoids, the palatal plates of the maxillaries meeting along the mesial line, form the second and most extensive area of the palatal vault. The next area of the vault consists, as in the Turtles, of the ethmoidal neurapophyses (the so-called "palatals"), united along the mesial line, and much elongated backwards. The posterior margin of the combined ethmoidal neurapophyses of the Turtle forms the central part of the free margin of the palate; but the completion in the Crocodile of the deflected outer margin and central ridge of the pterygoids into a double tube, or pterygoidean prolongation backwards of the nasal fossæ, produces a corresponding elongation of the palatal vault; which accordingly presents, behind its ethmoidal, an extensive and broad pterygoidean area, which thus completes the vault behind, as in certain Cetacea and Edentata. Among the Mammalia the great elongation backwards of the combined maxillary palatal plates, the corresponding elongation of the combined ethmoidal neurapophyses, and the great breadth of the pterygoidean area, have displaced the palate bones so far backwards and outwards, that, separated from the ento-pterygoids and the ethmoidal neurapophyses by a wide chasm, but retaining their connections with the maxillaries and pterygoids, and coming into contact with the malar, they are, in fact, extended from the walls of the nasal fossæ, and from the palatal vault, and, thus disguised, have been hitherto known only as "transverse bones," "adgustal bones," "pterygoïdes externes," "ecto-pterygoids."

The Nasal Passage of the Cyclostomous Fishes.—The cyclostomes differ from all other Fishes in possessing a tubular passage, which, opening externally above the oral disk, passes backwards to the combined olfactory capsules, and behind which it terminates in a cul-de-sac in the Lamprey, but in the Myxine and Bdellostoma, communicates with the alimentary and respiratory tract.

The form and arrangement of the cartilages, which enter into the formation of the walls of this tubular passage, have been figured and minutely described in the classical memoirs of Joh. Müller, on the Cyclostomous Fishes. It becomes a point of much interest to ascertain the morphological character of this tubular passage, and to determine the morphological relations of its cartilaginous elements.

The olfactory capsules of the Myxine, Bdellostoma, and Lamprey, are completely fused into one another at the mesial plane, so as to form a single chamber, situated immediately in front of, and in a line with, the cranial cavity. The common olfactory chamber communicates with the cranial cavity by two orifices perforated in the fibro-cartilaginous transverse septum, for the passage forwards of the olfactory nerves. The olfactory chamber opens below into the naso-pharyngeal passage. In the Lamprey this passage is membranous throughout, the portion in front of the olfactory chamber lying above the posterior superior oral shield, its posterior portion passing back between the base of the cranium and the central part of the palatal cartilage, terminates in a cul-de-sac at its pharyngeal extremity. In the Myxine and Bdellostoma the posterior portion of the passage is a membranous canal situated between the base of the cranium and the mesial palatal cartilage, and opens posteriorly into the pharynx. That portion of the naso-pharyngeal passage in front of the olfactory chamber is supported above and laterally by a series of ten cartilaginous rings, incomplete below—the entire arrangement closely resembling a Mammalian trachea. The membranous floor of this part of the passage is supported by the anterior portion of the central, and the transverse junction of the lateral palatal cartilages, and in front by the mesial and transverse superior oral cartilages.

The morphological constitution of this remarkable nasal skeleton appears to be similar to that of the nasal fossæ of the higher Vertebrata. The olfactory capsules have passed inwards, as in the Bird and Reptile, so that, instead of projecting from the sides of the cranium, like the auditory capsules, they occupy the space of the corresponding cranial segment. The incomplete cartilaginous rings of the nasal tube, viewed in their relations to the cranium and conjoined olfactory capsules, are in the position of a superadded series of neural arches, similar to the neural portions of the rhinal and vomerine Mammalian scleratomes, destitute, however, of centrums, but supported below by the peculiarly developed palatine and maxillary elements which have passed forward beneath them. The entire arrangement presents the general characters, or is developed on the plan of the nasal fossæ of the Reptile, Bird, and Mammal, with the additional peculiarity of an increase in the number of constituent segments, similar to that which apparently exists in the proboscidian Mammals.

Post-stomal Cephalic Sclerotomes. — *Their Central and Neural Elements.*—As the discrimination of the constituent central and neural elements of the three post-stomal segments of the skull demands a constant reference from the one segment to the other, I shall examine them together. Of these three segments, the post-sphenoidal, the temporal, and the occipital, the second has not hitherto been recognised except by Carus, whose system includes a temporal intervertebra.

My attention was directed to the temporal segment of the cranium by the remarkable indications of it presented by the human skull. The human occipital bone, in addition to that upper angular portion of its squamous plate, which presents the relations of the interparietal, exhibits all the characteristics of a vertebral centrum, in combination with neura- and meta-neurapophyses. The inferior articular processes of this cranial segment are largely developed, in relation to the atlas. But it has not been hitherto noted, that the so-called jugular processes are in fact its upper or anterior pair of articular processes; and that, consequently, the jugular processes on the posterior margins of the petrosal portions of the temporals must be the zygopophyses of the succeeding cranial segment. These occipital and temporal jugular articular processes, like the corresponding processes in the column below, present distinct cartilaginous articular facets, and are contiguous to the "foramina lacera posteriora" or "intervertebral foramina," formed by the conjunction of the temporal and occipital jugular fossæ, and which transmit, as in the spine, vessels and nerves. But the petrous portion of the human temporal bone has, in addition, a pair of distinct pro-zygopophyses. They are situated on the anterior margins of the petrous portions where these margins form the angles with the squamous portions, in which are situated the openings of the Eustachian tubes. The articular surfaces of these processes are perpendicularly striated, and are applied against corresponding surfaces of the so-called styloid processes of the sphenoid at the posterior angles of its great wings. These "styloid processes" are therefore the zygopophyses of the post-sphenoidal sclerotome. The pro-zygopophyses of the post-sphenoidal and the zygopophyses of the pre-sphenoidal may be observed at the forepart of the pterygo-palatine groove in the fœtal bone, but are more remarkably developed in the young Ruminant; in which also may be observed the zygopophyseal connection of the presphenoidal with the ethmoidal neurapophyses.

We have, therefore, in these zygopophyseal connections distinct evidence of five cranial segments—an ethmoidal, pre-sphenoidal, post-sphenoidal, temporal, and occipital, in addition to the vomerine and rhinal.

For the further development of this subject, the cranium of a Cyprinoid Fish should next be selected. If the lateral wall of the cranium be examined, either from the external or mesial aspect, five serially arranged neurapophyseal plates will be recognised, connected to one another by four distinct zygopophyseal articulations. These plates are, from before backwards, the so-called "pre-frontal," the "cranial ethmoid," the "orbito-sphenoid" of Owen, the "ali-sphenoid" of Owen, and the lateral accipital. I have already stated the grounds on which I believe we must look upon the "pre-frontals" of the Fish as the neurapophyses of the ethmoidal, and the "cranial ethmoid," as the combined neurapophyses of the pre-sphenoidal neural arches. If so, then, the succeeding plate must be the "ali-sphenoid," and not the "orbito-sphenoid," as Professor Owen considers it to be; and, therefore, as there has never been a question regarding the lateral occipital, the plate interposed between the latter and the former, as it has all the characters of a neurapophysis, indicates the existence of a cranial segment between the post-sphenoidal and occipital. I shall not at present allude to the various opinions entertained regarding this plate, but shall merely distinguish it as the inferior temporal neurapophysis.

Proceeding now to the consideration of the centrums corresponding to this series of neurapophyses, it must be observed that in no osseous Fish in any stage of development have more than three osseous pieces been observed in the basis of the cranium from the so-called "vomer" to the "basi-occipital" included. The assumed "connation" of the centrums of the pre- and post-sphenoids, as held by Professor Owen, has at present no support from embryology; the missing centrum or centrums must, therefore, be accounted for otherwise than by a hypothetical division of the "basi-sphenoid." Professor Owen appears, indeed, to a certain extent to admit this, for in certain Fishes he considers the symmetrical Y-shaped ossicle marked in his diagrams 9^1, and superimposed on the pre-sphenoidal process of his basi-sphenoid, as the central part; while that process itself he holds to be the capsular portion of the ossified notochord.

That mutual elongation and overlapping of the cranial centrums formerly alluded to, is strongly marked in Fishes, the sphenoidal centrum being dovetailed into and elongated beneath the occipital behind, and above the ethmoidal ("vomer") in front. The manner in which the anterior elongated portion of the post-sphenoidal centrum of the Bird elevates and carries on its upper surface the compressed pre-sphenoidal centrum, has already been stated; and I must again observe, that it appears to me that the pre-sphenoidal centrum exists in certain Fishes only in the form of a bar of cartilage—a portion of the "primordial cranium" situated on the upper surface of the anterior prolongation of the post-sphenoidal centrum, and terminating on the upper surface of the ethmoidal centrum or so-called "vomer;" and that in Fishes with an "ossified orbital septum" or "cranial ethmoid," it is to be recognised in the half-ossified cartilaginous mass which unites the right and left plates of that "septum," and which have been already indicated as its corresponding neurapophyses. The pre-sphenoidal is an undeveloped centrum in the Fish, retaining more or less of its "primordial" texture and form, and elevated, therefore, above, or carried inwards, so as to be covered by the fully developed ethmoidal and post-sphenoidal centrums.

I am acquainted with no example of a fully developed temporal centrum. It is represented in the "primordial cranium" by the quadrilateral cartilaginous plate, bounded laterally by the ear capsules, behind by the portion corresponding to the cartilaginous lateral occipitals, and in front by the part in which the post-sphenoidal centrum first appears. In all vertebrate animals this portion of the basis of the primordial cranium is of great comparative extent, and is encroached upon by the advancing ossification of the occipital and post-sphenoidal centrums in modes which vary in the different vertebrate forms. In Mammals, the occipital advances into it at the expense of the post-sphenoidal centrum. In Birds and Fishes, the post-sphenoidal passes more backwards. In the Reptiles, the two centrums appear to share it equally. In all the forms, I believe that traces of the intermediate or temporal centrum may be detected, either in the cartilaginous or osseous condition. In Fishes, more or less of the primordial cartilage remains above the junction of the occipital centrum, post-sphenoidal centrum, and temporal neurapophyses ("petrosals"), and covered more or less internally, or towards the cranial cavity, by the internal prolongations of the occipital centrum, and of the temporal and post-sphenoidal neurapophyses. The peculiar canal for the muscles of the orbit existing in certain fishes, and which is roofed over principally by the "petrosals," or temporal neurapophyses, appears to be hollowed out principally in the primordial temporal centrum, and to be lined by its constituent cartilage. The peculiar Y-shaped bone met with in the pike, perch, and salmon, marked 9^1 by Professor Owen, and * by Hallman, and considered by the former as that portion of the pre-sphenoidal centrum which results from the ossification of the corresponding central portion of the notochord, appears to me to be a central element; but referable rather to the post-sphenoidal or temporal, than to the pre-sphenoidal segment. For, in the first place, it may be questioned whether the corda dorsalis of the Fish reaches the region of the pre-sphenoid; and, in the second place, if I am correct in my determination of the post-sphenoidal and temporal neurapophyses of the Fish, the two ascending limbs of this bone abut against these latter elements, and are not at all connected with the pre-sphenoidal neurapophyses. As, moreover, these ascending limbs of the bone in question are more intimately connected with the bones which Professor Owen considers to be the ali-sphenoids, but which I must hold to be the inferior temporal neurapophyses, I am inclined to conceive it as ossified portion of the temporal centrum.

With regard to the bone termed by Hallman os innominatum, which is small but well marked in the carp, and larger in the perch, and which Professor Owen considers to be the petrosal, I quite agree with him. But while I do so, I make a distinction between an ossified portion of the auditory capsule and the bone which constitutes the corresponding neurapophysis, in the same manner as I find myself compelled to admit the independent existence of the ethmoidal neurapophysis and the olfactory capsules, whether fibrous, cartilaginous, or osseous, and the corresponding independent existence of the variously modified sclerotics and the orbito-sphenoids.

Proceeding now to the examination of the remaining elements of the post-stomal neural arches in the Fish, I would observe that if we put aside those conceptions of the constitution of the arches in question, derived from previous study of the cranium of the Mammal, the constitution of the corresponding arches in the Fish, which naturally suggests itself, is the following:—

1. Over the occipital centrum, the lateral occipitals and the external occipitals—as two pairs of neurapophyses; and the superior occipital—as a single meta-neurapophyses.

2. Over the position of the temporal centrum, the bones termed petrosals by the continental anatomists, but by Professor Owen petrosals in the cod, and ali-sphenoids in the carp, and over these the mastoids, these "petrosals" or "ali-sphenoids," along with the mastoids—as two pairs of neurapophysis; and the contiguous or separated bones usually termed "parietals," as a divided meta-neurapophysis.

3. Over the great basi-sphenoid, the bones termed by Professor Owen orbito-sphenoids in the carp, and ali-sphenoids in the cod, with the post-frontals—as two pairs of neurapophyses, the meta-neurapophyses being absent.

Before making any statements in support of this view of the constitution of the post-stomal neural arches in the cranium of the osseous Fish, I would direct attention to the corresponding parts in the other Vertebrata, from the same point of view.

In the Bird the occipital neural arch wants the ex-occipitals. The temporal arch possesses no centrum, but the petrosals, mastoids, and parietals, are placed one over the other as two pairs of neurapophyses and a divided meta-neurapophysis. The post-sphenoidal centrum is surmounted by the post-sphenoidal wings and the feebly-developed post-frontals—as two pairs of neurapophyses; while the meta-neurapophysis is deficient.

In the Crocodiles, the occipital arch, as in the Birds, has lost the upper pair of neurapophyses. The temporal centrum is not developed, but the two pairs of neurapophyses, and an undivided meta-neurapophyses—the petrosals (ali-sphenoids of Owen), mastoids, and so-called parietal—form a continuous arch. The post-sphenoidal centrum is again found to carry two pairs of neurapophyses, the great sphenoidal wings (orbito-sphenoids of Owen), and the post-frontals. The meta-neurapophysis is missing.

In the Chelonians, the occipital arch consists of one pair of neurapophyses and a meta-neurapophysis surmounting a centrum. The temporal centrum is not developed. The inferior pair of neurapophyses, the so-called ex-occipitals, abut externally against the mastoids, and are thus connected with the largely developed so-called "parietals." These "parietals" not only form a large part of the cranial and temporal vaults, but send down laminæ to rest on the pterygoids, and thus enter into the formation of the lateral walls of the cranial cavity in front of the post-sphenoidal wings. Above the post-sphenoidal centrum, the post-sphenoidal wings and the post-frontals rise in connection with one another, as two pairs of neurapophyses, but the meta-neurapophysis is again wanting.

In the Ophidians, the occipital centrum is again surmounted by one pair of neurapophyses and a meta-neurapophysis. The temporal centrum has disappeared behind the basi-sphenoid; but the well-developed so-called "petrosals," the ali-sphenoids of Professor Owen, are surmounted by the elongated and nearly extruded mastoids; while the single meta-neurapophysis, the undivided "parietal," is so largely developed, that, passing down as in the Chelonian to the basis of the cranium, it rests upon the post-sphenoidal centrum over a great extent in front of its own neurapophyses, so as altogether to obliterate the post-sphenoidal wing. The post-sphenoidal centrum is there cut off from the post-frontals, which constitute the only remaining elements of its neural arch.

In the Lacertians, the occipital centrum, with its pair of neurapophyses and single neurapophysis, is followed by a temporal arch, without a centrum, but with two pairs of neurapophyses, "petrosals," and mastoids, and an undivided meta-neurapophysis or "parietal," generally single in front, but projecting backwards, with the mastoids on each side behind. The post-sphenoidal centrum is not surmounted by ali-sphenoids, except the parietal columella represent these elements. The post-frontals again appear; but without a corresponding meta-neurapophysis.

In the Frogs, the occipital centrum and the corresponding meta-neurapophyses have disappeared; a single pair of neurapophyses constituting the sole osseous elements of the arch. The temporal centrum appears in the primordial cartilage which extends across on the upper surface of the posterior part of the much-elongated "basi-sphenoid," and between the cartilaginous auditory capsules. The latter are intimately connected to the inferior temporal neurapophyses, the ali-sphenoids of Professor Owen, with which feebly developed mastoids or superior neurapophyses are conjoined; the whole being surmounted by the greatly developed antero-posteriorly elongated so-called "parietals," which dip down slightly at their margins, in front of the temporal region towards the "basi-sphenoid," as in the Chelonians and Ophidians. The portions of the post-sphenoidal wings and the post-frontals are occupied by fibrous texture; the "basi-sphenoid" or post-sphenoidal centrum extending forwards below; and the "parietals" taking the place of the deficient meta-neurapophyses.

The preceding view of the arrangement of the centrums and neural arches of the post-stomal sclerotomes of the lower forms of cranium, is that which would appear naturally to suggest itself to a mind uninfluenced by the arrangement of the corresponding region of the Mammalian skull. It is assumed throughout, that there are more or less complete cartilaginous or osseous auditory capsules in addition to corresponding neurapophyses; and that these neurapophyses are not post-sphenoidal but temporal, as evinced by their zygapophyseal connections in the human cranium. No reference has been made to the relations of the contested "petrosals" and "ali-sphenoids" to the fifth nerve, because, while the fundamental relation of that nerve to the post-sphenoidal sclerotome is admitted, the divisions of the nerve exhibit the same tendency to vary in their points of exit, as is presented by the other cerebral nerves; moving backwards more or less across the corresponding neurapophyses, and notching or perforating the neurapophyses behind. In fact, until a more minute investigation of the development of the cranium in its relations to the cerebral nerves has afforded some explanation of the varied relations of these parts in the series, we cannot, in my opinion, attach much weight to the determination of a "petrosal" or an "ali-sphenoid" by means of their relations to the trigeminal nerve.

Proceeding now to the examination of the post-stomal centrums and neural arches of the Mammalian cranium, let the Human skull be selected for examination. The occipital centrum is surmounted by a pair of neurapophyses and a double meta-neurapophysis. But again, surmounting the meta-neurapophyses there is a double piece, which occasionally remains permanently separate from the "occipital bone." This double piece, or pair of bones, present the relations of the interparietal bones in lower Mammalia. They may extend laterally to join the "mastoids," or they may be connected to the latter by a more or less continuous chain of "triquetral bones" in the line of the lambdoidal suture.

The zygapophyseal attachments of the "petrous portions of the temporal bone" indicate these masses to be neurapophyses enveloping the ossified auditory capsules. Keeping out of view the "squamous," "tympanic," and "styloid" portions of the "temporal bones," the "mastoidal portions" become early and intimately connected with the "petrous portions." Commencing with the "petrous portions," as an inferior pair of temporal neurapophyses, they are surmounted, as in the lower Vertebrata, by the "mastoidal portions" as a second pair of neurapophyses, while the arch is closed by the double element which forms the upper angle of the "occipital bone," as a meta-neurapophysis. There are well-marked indications of a temporal centrum in the human cranium. The irregularly truncated apices of the "petrous portions," directed obliquely forwards and inwards, are continuous, by means of the fibro-cartilaginous remains of the basis of the "primordial cranium," which occupy the "foramina lacera media," with the inclined plate of bone which, in the plane of the "basilar process of the occipital" or occipital centrum, forms the back part of the "body of the sphenoid," including the "posterior clinoid processes." This plate of bone is frequently surrounded by a deep groove, the posterior part of which lodges the "transverse venous sinus," and I have seen it nearly detached.

The feebly developed post-frontals in the Bird have disappeared in the Mammal, so that the post-sphenoidal centrum is surmounted by the "ali-sphenoids," as a single pair of neurapophysis; and by the enormously expanded double meta-neurapophysis in the Human subject, or the less developed form of parietals in the Mammalia generally.

The fundamental facts on which the preceding determination of the comparative constitution of the post-stomal neural arches of the cranium depends, are the zygopophyseal connections of the human "petrosals." If the "petrosals" even in one species can be proved to present the characters of neurapophyses, the sclerotome to which they belong must exist in addition to those to which the "ali-sphenoids" and "orbito-sphenoids" are referable. The existence of temporal neurapophyses explains the existence of interparietal, in addition to parietal bones in the Mammal; both of these meta-neurapophyses taking part in the protection of the developed cerebrum; while the non-appearance of the anterior or spheno-parietal in the Bird, Reptile, and Fish, accords with the complete development of the posterior or temporo-parietal, repressed in the former by the influence of the cerebrum, and by the full development of the ethmoido-frontal. I base my determination of the separate existence and reciprocal development of ethmoido-frontals and spheno-frontals, of spheno-parietals and temporo-parietals, not only on my analysis of the bones themselves in the series, but also on the evident reciprocal influence which the superimposed cerebral mass in the Mammal, and the bulky organs of sense and uncovered sense-ganglions of the lower Vertebrata have on the cranial neural arches. I believe also, that in this as in other departments of inquiry, we are apt to look for greater simplicity and uniformity in details than actually exist. The simplicity of natural law consists in the comprehensiveness of its general principles. In tracing these principles into details, the complexity is found to be infinite.

The Hæmal Arches of the Post-Stomal Cephalic Sclerotomes.—The clue by means of which we can alone be safely guided to the morphological constitution of these arches, in the midst of the varied complexity which they present to the comparative anatomist, is afforded by embryology. The hæmal arches of the post-stomal sclerotomes are developed each in the corresponding pair of "visceral laminæ." By endeavouring to ascertain, therefore, in which of these post-stomal "visceral laminæ" the sclerous elements of the varied forms of the post-stomal hæmal arches are originally formed, the morphological constitution of the individual hæmal arches may reasonably be anticipated. If, again, I am correct in my determination of the constitution of the pre-stomal sclerotomes, the allocation of the individual post-stomal hæmal arches to their proper centrums and neural arches follows as a matter of course.

From the observations more particularly of Rathke and Reichart, the formation of the osseous elements of the post-stomal hæmal arches in the "visceral laminæ," is preceded in each by a more or less distinct and continuous cartilaginous streak or band. Rathke found seven pairs of these cartilaginous streaks loosely connected to the basis of the embryo head of the *Blennius viviparus* and corresponding to the mandibular, hyoidean, first, second, third, and fourth branchial and pharyngeal arches. In the Adder the same indefatigable embryologist and comparative anatomist found a cartilaginous style, with a process directed forward in the position of the maxillary, palate, and pterygoid bones, embedded in the first visceral lamina and its "superior maxillary process," and attached to the side of the basis of the primordial cranium in front of its auditory region; a similar style lay in the second visceral lamina, and was firmly attached to the base of the cartilaginous cranium behind, and external to the auditory capsule; a third style lay in the third visceral lamina, and was also firmly attached like a rib to the occipital region of the primordial cranium. Similar primordial hæmal arches have been found by Reichart in the visceral laminæ of the Mammal and Bird, and by numerous observers in the Amphibia. It is important to observe again at this point, that the relations of all these seven pairs of primordial hæmal arches are similar. Firstly, all the visceral laminæ in which they are developed appear to consist of the serous, vascular, and mucous layers united; secondly, the cartilaginous streaks are formed towards their inner surfaces, under the mucous layer; thirdly, the heart and vascular arches are on their exterior, under the serous layer.

First Post-Stomal Hæmal Arch.—The constitution of this arch must be determined by the examination of the development of the first post-stomal visceral lamina. It has been already stated that the process usually considered as the upper part of the so-called "first visceral lamina" is, if its general relations be taken into account, the posterior pre-stomal visceral lamina in which the pre-sphenoidal hæmal arch is developed.

The cartilaginous streak in the first post-stomal visceral lamina of the Mammal divides into two portions. The superior and smaller of the two becomes the incus. The long inferior portion is the cartilage of Meckel; around the lower part of which the corresponding half of the lower jaw is developed; the upper part forms the slender process and the head of the malleus. As the Eustachian tube, the tympanum, and the external auditory passage, consist of the persistent upper portion of the first visceral cleft, the cartilage of the Eustachian tube, and the tympanic bone, which are continuous with one another, and form the floor of these three spaces, are developed in blastema deposited near the upper extremity of the cleft. This blastema also forms the membrane of the tympanum, into which the handle of the malleus shoots. It is to be observed that this lower jaw and tympanic bone do not originate in the primordial cartilaginous streak, but in blastema deposited around it. The tympanic bone forms at first an inverted arch across the visceral cleft, or a ring incomplete above, which supports the membrane of the tympanum on the outer side of the attenuated portion of Meckel's cartilage, which connects the malleus to the inner side of the jaw. It then extends inwards, so as to form the floor of the tympanum and Eustachian tube, folding up before and behind, and thus inclosing the incus and malleus leaves, the latter connected to the jaw through the tympanic fissure.

The development of the first post-stomal visceral lamina appears, therefore, to indicate at least four elements on each side of the mandibular hæmal arch in the Mammal. The tympanic element is probably complex; the mandibular consists of at least two portions, one on the outer, the other on the inner side of the corresponding portion of Meckel's cartilage.

In the Bird the omoid and palate bones are formed like the pterygoid and palate bones of the Mammal, in the so-called "superior maxillary process." In the proper first post-stomal visceral lamina, the primordial cartilaginous streak divides, as in the Mammal, into two portions. The upper and smaller of the two becomes the quadrate bone; the lower and longer portion—Meckel's cartilage—becomes enveloped in the corresponding half of the lower jaw; but instead of the upper end of this portion forming the slender process of a malleus, it remains as the peculiarly-formed articular piece of the jaw itself. The original intimate connection of the rudiment of the pterygoid bone, in the so-called "superior maxillary process," with the upper or incudal portion of the primordial cartilaginous streak of the first post-stomal visceral lamina of the Mammal, speedily diminishes; but in the Bird, not only does the pterygoid or omoid bone rapidly increase in relative size and configuration; but the quadrate portion of the first visceral streak does so likewise. The latter also exhibits, attached to its outer side, as the omoid is to its internal process, a styliform ossicle, the rudiment of the quadrate-jugal bone, which again is connected anteriorly to the jugal.

Reichart, who has minutely described and figured the development of this visceral lamina in the Bird, makes no allusion to the remarkable indication which it affords of the signification of the quadrate bone, and articular piece of the lower jaw. It affords, as it appears to me, sufficient evidence that the quadrate bone of the Bird is the homologue of the Mammalian incus, and that the articular piece of its lower jaw is the homologue of that ossified portion of the upper end of Meckel's cartilage, which in the Mammal forms the slender process of the malleus.

The quadrate bone has been hitherto considered as the homologue of the tympanic bone in the Mammal, not only from the proximity of the latter to the condyle of the jaw, but chiefly from its presumed absence in the skull of the Bird. But there appears to me to be sufficient evidence of its existence, not only in the fibro-cartilaginous frame which connects the margin of the tympanic membrane to the mastoid, lateral occipital, and basi-sphenoid, but more particularly in the thin well-defined lamina of bone, which, apparently united to its fellow of the opposite side, forms the floor of the tympanic cellular space in the broad posterior portion of the basi-sphenoid. As these apparently united laminæ are continuous with the single cartilaginous Eustachian tube, below the single or double osseous Eustachian orifice, I am induced to believe that they will turn out to be the feebly developed representatives of the tympanic bones of the Mammal.

By a very beautiful analysis Professor Owen has proved that the quadrate-jugal bone of the Bird is the homologue of the squamous portion of the Mammalian temporal. I cannot, however, give my assent to his determination of its special homology, as a portion of the subdivided radiating appendage of the maxillary arch. Its relations in Birds and Crocodiles, in which it presents all its fundamental connections, appear to me to show that it is an anterior actinapophysis of the mandibular arch; passing forwards to abut against the malar, which I have already stated to be a posterior actinapophysis of the ethmoidal hæmal arch, or as in the Lacertians against the post-frontals. The squamous portion of the quadrate-jugal bone is a Mammalian superaddition, to adapt it to the part it takes in the formation of the cranial wall. It is withdrawn therefore from the quadrate or incudal portion of the mandibular arch (which portion diminishes relatively), and passes—as the entire bone does in the Lizards—upwards to be connected with the cranial wall. The development of the first post-stomal visceral lamina in the Bird appears therefore to afford evidence that the mandibular hæmal arch in the Bird and Mammal includes a tympanic element, a quadrate or incudal, a malleal or articular, and the elements of the corresponding side of the lower jaw.

On the same grounds I am inclined to believe that the articular piece of the lower jaw of the Reptile and Amphibian is malleal like the corresponding piece in the Bird, and not the homologue of the condyle of the Mammalian jaw. They are all malleal portions of Meckel's cartilage retained in connection with the jaw. In like manner, I am inclined to believe that the so-called tympanic bone of the Reptile and Amphibian, like the quadrate or so-called tympanic bone of the Bird, is not the homologue of the tympanic bone in the Mammal, but of the incus. The incus of the Mammal has been set free from its fundamental quadrate-jugal and pterygoid connections to co-operate with the similarly released malleus in the economy of the ear. The absence of proper tympanic bones in the Reptile and Amphibian is explained by the absence or feeble development of the tympanic cavity. I am inclined to think, however, that traces of them may be detected under and between the basi-sphenoid and occipital of the Crocodile, in the walls of those canals which connect, as Professor Owen has shown, by a common tubular communication, the sella turcica and the tympanic cavities with the basis of the cranium.

The tympanic systems and lower jaw of the osseous Fish form together a well-marked hæmal arch, developed in the first post-stomal visceral lamina of the embryo. From what has already been stated regarding the sclerous elements which result from the development of this visceral lamina in the other vertebrata, Professor Owen's view of the tympanic system of the osseous Fish, as the teleologically divided homologue of the quadrate bone of the Bird, and tympanic bone of the Reptile, would appear to require additional evidence. We are not yet in possession of materials for a rigorous determination; but it appears extremely probable that the tympanic bones of the osseous Fish are morphological, as well as teleological elements. If the articular piece of the lower jaw be assumed as the malleal portion of the persistent cartilage of Meckel, the hypo-tympanic occupies the position of the incudal element, connected, as usual, with the pterygoid. The epi-tympanic is in the position of the proper tympanic element of the Mammal, while the pre-tympanic, in its relations to the hypo-tympanic and pterygoid, closely resembles the quadrate-jugal or synamosal.

The opercular bones form on each side of the mandibular arch a series of actinapophyseal elements, which, from the view already taken of such elements, would appear to be posterior, as the quadrate-jugal or squamosal is anterior in relation to the sclerotome. With regard to any traces of these opercular or actinapophyseal elements in the mandibular hæmal arch of the higher vertebrata, I must agree with Carus in considering the cartilages of the external ear in the Mammalia as homologous with them. The objection of Rathke to this determination of Carus—that the cartilage of the concha is attached to the tympanic bone so as to be situated at the back of the auditory foramen, that is, at the posterior margins of the first visceral cleft—appears to me to be met by taking into account the peculiar curved form which the tympanic element assumes in passing from before backwards across the cleft.

The allocation of the mandibular hæmal arch to the post-sphenoidal, or first post-stomal sclerotome, follows from the analysis already made of the pre-stomal sclerotomes.

The Second and Third Post-Stomal Hæmal Arches.—As the researches, more especially of Rathke and Reichart, on the development of the first visceral lamina, afford a clue to the constitution of the corresponding hæmal arch; the labours of these observers in like manner indicate the nature of the second and third arches. These arches are developed in the second and third visceral laminæ, and, from the varied forms which they present in the series, could only have been determined by an appeal to embryology.

In the Mammal the primordial cartilaginous streak in the second visceral lamina, and which is attached superiorly to the auditory region, divides into segments, the uppermost of which becomes the stapes; while the succeeding become, in succession with the intermediate soft portions, the "stapedius muscle," the pyramid and its prolongation downwards, the styloid process, the stylo-hyoid ligament, and the series of sclerous elements which terminates below in the anterior horn of the hyoid.

The primordial cartilaginous streak in the third visceral lamina is attached to the occipital region, breaking up into four segments; the two upper disappear; the two lower become respectively the posterior horn and corresponding half of the body of the hyoid.

In the second visceral lamina of the Bird, in like manner, the auditory columella is developed superiorly, and the feeble anterior horn of the hyoid below, while the elements of the suspensory or posterior horn of the hyoid are formed in the third visceral lamina. The fibrous septum of the tongue and the epiglottis of the Mammal make their appearance in the line of junction of the second and third visceral laminæ. The respective share taken by these two laminæ in the formation of the so-called basi-glosso- and uro-hyals in the Bird remains to be determined.

The precise observations of Rathke have shown that the lateral halves of the feebly-developed hyoid of the Ophidian are formed by the lower portions of the primordial cartilaginous streaks of the second pair of visceral laminæ, while the auditory columellæ are formed in their upper portions. Rathke also found that the primordial cartilaginous streaks of the third pair of visceral laminæ, and which are attached to the occipital region, disappear altogether.

There are no embryological observations in sufficient detail to indicate the morphological relations of the more or less complex hyoid apparatus in the Chelonian and Lacertian. The so-called hyoid, or suspensory arch of the branchial apparatus in the Amphibia is developed in the second pair of visceral laminæ. The corresponding arch in the Tadpole, and the anterior or suspensory horn of the so-called "hyoid" of the Frog, are also developed in this pair of visceral laminæ. The suspensory arch of the branchial apparatus is attached to the quadrate, or so-called "tympanic" piece of the mandibular arch, and not to the base of the cranium. Rathke had observed a filament extending between the auditory region of the cranium and the quadrate cartilage of the Tadpole. He found that the so-called "malleus and incus" are developed in this filament. According to Reichart, this filament appears to be the upper part of the second primordial cartilaginous streak, which, in consequence of the peculiar manner in which it curves forward superiorly towards the quadrate cartilage (a curvature of the same kind towards the quadrate bone has been observed by Rathke in the Adder), becomes attached to it. In consequence of this attachment, the hyoidean arch becomes suspended to the quadrate portion of the mandibular; and the upper portion, between the quadrate cartilage and the auditory region of the skull, becomes converted into those elements in the Frog, which have their homologues in the stapes of the Mammal, and the columella, with its cartilaginous extremities, in the Bird and Reptile.

As the cartilaginous branchial arches of the Tadpole, and of the other Amphibia, are formed in the succeeding visceral laminæ, it would appear to follow, as a necessary consequence, that the suspensory or hyoidean arch of the Amphibian, with its inferior mesial element, and along with the auditory ossicles, is homologous with the anterior or suspensory part of the hyoid, along with the stirrup-bones in the Mammal, and with the corresponding structures in the Bird and Serpent; and that the first branchial arch of the Amphibian, with its corresponding inferior mesial elements, are homologous with the posterior horns and body of the hyoid in the Mammal, and with the posterior or suspensory horns, with the corresponding inferior mesial elements of the hyoid in the Bird. The so-called posterior horns of the hyoid of the Frog cannot, therefore, be the homologues, as Professor Owen's statements might lead us to infer, of the posterior horns of the hyoid of the Mammal or Bird. The posterior horns of the hyoid of the Frog are the remains of its posterior pair of branchial arches, or enlargements of the posterior angles of its basi-hyals. They are developed therefore in its posterior visceral laminæ; while the posterior hyoidean horns of the Mammal and Bird are developed in the third pair of visceral laminæ.

As the skeleton of the hyoidean and branchial apparatus of the Fish is developed in the form of a series of inverted arches in the corresponding visceral laminæ, from the second inclusive, we are obliged to conclude that its hyoidean arch is the homologue of the stylo-hyoidean arch, with the stirrup-bones,—or second post-stomal arch—in the Mammal; and of the corresponding portion of the hyoidean apparatus in the Bird, with the columellæ; and of the entire hyoid in the Serpent, with the columellæ; and that the first branchial arch in the Fish is the homologue of the corresponding arch in the Amphibian; of the posterior horns of the hyoid, and their associated elements in the Bird; and of the posterior horns and body of the hyoid in the Mammal.

It has not yet been determined upon what developmental change the suspension of the hyoidean arch of the Fish to its mandibular arch depends. It is probably of the same nature as that which occurs in the Tadpole, with this difference, that the upper portion of the hyoidean arch disappears in the Fish, without developing a stapedial ossicle; while its lower portion remains permanently connected to the mandibular arch, instead of regaining an attachment to the cranium.

The hyoidean and branchial arches of the Fish are provided, as has been already stated, with a well-developed double series of actinapophyses, for the support of the branchiostegal membrane, and the branchial laminæ. These actinapophyses in the Fish are foreshadowed in the Tadpole by the tubercular margins of its branchial styles.

The question may now be put—if we are brought by reference to the development of the parts to allocate to the three post-stomal sclerotomes, hæmal arches, consisting respectively of the sclerous parts developed in the three anterior post-stomal visceral laminæ, to what sclerotomes are we to refer the potential or actual hæmal arches in the remaining visceral laminæ? For reasons already stated, they cannot be disposed of by referring them to a splanchno-skeleton, because in that case the hyoidean arch or arches, and apparently the mandibular arch also, must be referred to the same category. Neither can they be referred to any of the cervical, or trunk sclerotomes; because it would appear that the visceral walls of the head are alone perforated by clefts. We are not yet prepared to answer the question. It involves, as it appears to me, the investigation of a residual quantity, the solution of which will require some information in reference to certain points, regarding which we cannot at present be said to possess any. First, the development of the Cyclostomes, but more especially of Branchiostoma; secondly, the mode in which the trunk sclerotomes increase in number and become arranged in groups; thirdly, the mode in which the same changes proceed in the cranium; fourthly, the determination of the series of cephalic nervous centres, with their corresponding nerves (neurotomes), more especially in the medulla oblongata, with the causes which determine the grouping and order in which the cerebral nerves pass through the walls of the cranium.

If there appears to be no sufficient developmental grounds for making a distinction between the branchial arches of the Amphibian and Fish, as belonging to a splanchno-skeleton, and the hyoidean and mandibular as referable to the neuro- or endo-skeleton, it becomes important to determine the signification of the sclerous elements of the larynx, trachea, and bronchial tubes. Without presuming to anticipate the minute observation of the development of the parts themselves necessary for the solution of a question of this kind, I would venture to suggest that the proper cartilages of the larynx are developed from the inferior or mesial extremities of certain of the visceral laminæ; and that the cartilages of the trachea and bronchial tubes are a pair of highly developed actinapophyseal systems, referable to one of the posterior visceral arches.

Post-stomal neuractinopophyses.—In addition to the auditory capsules, I recognise as post-stomal neuractinopophyses more particularly those ossicles attached to the post-frontals, mastoids, and external occipitals of Fishes. Those attached to the post-frontals may enter into the formation of the infra-ocular bony arch. Those, again, which are developed on the temporal and occipital sclerotomes are modified so as to co-operate in the cranial suspension of the scapular girdle.

In conclusion, Goethe was the first to indicate the intermaxillaries, the maxillaries, and palatals, as elements of three distinct cranial segments. In the course of my investigation of the development of the teeth I became early aware of the correctness of Goethe's views on this subject, and have found myself, therefore, unable to coincide with the doctrine of Professer Owen as to the constitution of his palato-maxillary or nasal hæmal arch.

3. *On the Morphological Constitution of Limbs.*

Carus, maintaining generally the doctrine of cephalic limbs, originally propounded by Oken, has at the same time given much greater precision to the conception of the skeleton of a limb, by viewing it as a system of elements radiating from the exterior of a costiform arch. Professor Owen, while he rejects with British and the majority of Foreign anatomists, the fantastic doctrine of Oken and his immediate followers with regard to cephalic limbs, has adopted the general doctrine of the skeleton of the limb as propounded by Carus, and has developed and applied it with much ingenuity to the illustration of actual structure. Professor Owen has, however, at the same time, by his allocation of the scapular girdle to the occipital segment of the cranium, as its hæmal arch, and by the view which he takes of the opercular and brancheostegal elements, actually reproduced the doctrine of cephalic limbs in another form. I do not propose in this communication to examine in detail the grounds on which Professor Owen's general doctrine of limbs is based, but shall merely state categorically those considerations which appear to me to render it untenable.

1. It is highly improbable that the sclerous elements of a limb should be derived from one, or at most two, sclerotomes, while its other elements, and more especially its nerves, are supplied by a greater number of somatomes.

2. It appears to be highly improbable that the bones which enter into the structure of an arm or leg, or that the corresponding sclerous parts in the lower animals should be the result of teleological subdivision of a single "diverging appendage" or "archetypal element." Professor Owen virtually admits that these "teleological" elements have a morphological value when he institutes an inquiry into their "special" and "serial homologies."

3. It appears to me that the scapular girdle cannot be the hæmal arch of the occipital segment of the head—firstly, because that segment is already provided with a hæmal arch in the series of transitory and persistent sclerous elements developed in the third pair of visceral laminæ; secondly, because the scapular girdle is invariably found to be developed at or in the immediate neighbourhood of that part of the trunk of the animal where it is ultimately situated; and, thirdly, because it is improbable that the exceptions to a general law should be more numerous than the instances in which it is adhered to.*

The germs of the limbs make their appearance when the ventral laminæ of the primordial vertebral system are passing down towards the hæmal margin. At first they resemble lappet-like projections of the inferior margins of these laminæ; they extend along at least four or five of their segments, and are situated in those regions of the body to which the future limb is attached, viz., in the pelvic and posterior region of the neck, except in the Fish, in which the pectoral lappets are situated close behind the head. As the ventral laminæ extend downwards, the lappets retain a position more or less elevated on the side of the trunk. At this stage they also begin to exhibit a change in their form and position. They become first sessile, then pedunculated, and the peduncle then indicates by an angle at its centre the formation of the central joint of the shaft of the future limb—the elbow or knee-joint. At the same time, what I term the plane of the limb is changed. The lappet was originally developed in a plane, which is coincident with the axis of the corda dorsalis. This is the primary or fundamental plane of the limb; and when in this plane the lappet presents its radial or tibial margin forwards towards the head, and its ulnar or fibular margin backwards. When the limb leaves its primary position, it lies in its secondary plane, which cuts the corda dorsalis more or less obliquely, so that the radial or tibial margins of the limb are directed more or less forwards and inwards, and the ulnar and fibular backwards and outwards. The permanently sessile pectoral lappets or fins of the osseous Fish exhibit a peculiar modification of the same movement;

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* It is somewhat remarkable that the only embryological evidence which Professor Owen adduces in support of that portion of his Doctrine of Limbs, in which the anterior limb is assumed to be developed at or close to the head, is a reference to a passage in Rathke's Entwickelung der Schildkröten, in which the author adduces the *fundamental position* of the bones of the shoulder—viz., the posterior region of the neck—as a circumstance tending to explain their ultimate passage into the thoracic cavity.

they rotate on a transverse axis, so that their anterior or radial margins are directed downwards and their ulnar margins upwards. In the Sharks and Rays the pectoral and abdominal fins continue permanently in the primary plane.

While the lappet is still in its primary plane, the rudiments of the girdle of the future limb may be detected under the integumentary covering, and therefore external to the proper mass of the visceral wall of the body. In the primordial condition of the lappet of the wing of the Chick, Remak has detected four parallel streaks running to its outer margin, and continuous internally with the rudimentary nervous structures of the four primordial vertebræ, with which the attached margin of the lappet is connected.

Guided by embryological facts and conclusions, to the more important of which I have just alluded, I have endeavoured to detect, more particularly in the osseous Fishes, Plagiostomes, Amphibians, and Reptiles, the principle which lies at the basis of the morphology of limbs. The view which this inquiry has induced me to take of the subject I shall, in conclusion, state very briefly.

1. A limb does not necessarily derive its elements from one somatome—about fifty segments of the trunk appear to contribute towards the structure of the great pectoral fin in the Ray.

2. The nervous elements of the limbs appear, as in other parts of the vertebrate animal, to indicate most distinctly the morphological constitution of the sclerous elements. About fifty spinal nerves contribute the greater part of their hæmal divisions to the pectoral fin of the Ray; and there are about one hundred fin-rays—a pair of fin-rays to each nerve, and derived from each sclerotome. This correspondence does not apparently exist between the fin-rays and nerves of the osseous fish; but it may be fairly assumed that when we have detected the developmental circumstances which induce the attachment of the pectoral girdle of the osseous Fish to its cranium, as well as those peculiarities exhibited by its anterior trunk sclerotomes, this discrepancy will be explained. A more careful analysis than we yet possess of the number of spinal nerves which supply branches to the limbs of the higher Vertebrata is still a desideratum in this department of the subject; but it appears to be extremely probable, that in the Mammalia, at least five spinal nerves transmit filaments to the five distal divisions of the limb. It would appear, too, that, notwithstanding their plexiform arrangement at the attached end of the limb, the greater number of the filaments of each nerve reach their own morphological district at the distal part of the limb. The radial and the ulnar nerves are formed principally by the upper and lower roots of the human brachial plexus, that is, from the nerves of the upper and lower primordial segments with which the embryo limb was connected, and from which it derived its various elements.

3. The nerves supplied to a limb are not the inferior or hæmal divisions of the spinal nerves, but radiating on actinal branches of these divisions. The intercostal nerves are not the nerves serially homologous with the roots of the brachial plexus. The thoracic nerves, serially homologous with these roots, are the intercosto-humeral and the succeeding middle intercosto-cutaneous.

4. Each sclerotome supplying elements to the structure of a limb supplies as a sclerous element a single actinapophysis; or, as in the Rays, an anterior and a posterior—that is, a pair of actinapophyses.

5. From the structure of the mesial and lateral fin-rays of the Fish, the actinapophyseal elements of a limb may be assumed as primordially segmented.

6. The fin-rays in the Fish, and the phalangeal, metacarpal, and metatarsal bones of the higher vertebrata, are more or less persistent con-

ditions of the distal segments of the primordial actinapophyseal elements of a limb.

7. By atrophy, or otherwise, one or more of the segments in the successive transverse rows of actinapophyseal elements disappear, so as to leave in Man, *e.g.*, four elements in each carpal row; two in the fore-arm; one in the arm; two in the next row for the coracoid and clavicle; one in the proximal row for the scapula.

8. The nature of the subsequent changes, which the elements of the limb undergo, up as far as the shoulder or hip, may be inferred from an examination of the paddle of the Enaliosaur or Cetacean.

9. A careful application of the hypothesis to the limb girdles of the cartilaginous Fishes, Amphibia, and Reptiles, leaves me strongly inclined to believe that the coracoid is an actinapophyseal segment between the humerus and scapula, prolonged downwards, towards the hæmal margin of the body; that the scapula is a proximal element, elongated towards the neural margin of the body; that the clavicle is the only other retained element in the same transverse row as the coracoid, in front of it, and elongated like it in the hæmal direction; and that the corresponding elements of the posterior limb have a similar morphological signification.

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*American Association for the Advancement of Science.**

Tenth Meeting. Albany, August 20-27, 1856.

As regards the number of persons present, and the interest shown by the citizens generally in the proceedings, this meeting was probably the most successful which the Association has yet had.

The scientific papers and discussions, considered as a whole, give evidence of active and varied research; but while including important contributions to knowledge in numerous special departments, they present no general results of very striking novelty or interest.

The principal rooms of the State Capitol, a spacious building in the centre of the city, were devoted to the purposes of the Association, the Hall of Representatives being used by the general meetings, and at other times by the Section of Geology; the Senate Chamber by the Section of Physics and Mathematics, and the contiguous rooms by the Divisions of Chemistry, Zoology, &c. Nearly all the meetings, sectional as well as general, were attended by numerous spectators of both sexes, and in many cases the rooms were thronged with intent listeners.

The popular interest of the Albany meeting was not a little enhanced by the public inauguration of the *State Geological Museum*, and yet more by that of the *Astronomical Observatory*. The latter, recently endowed by the liberality of several of the citizens, and especially by the munificent gifts of Mrs Dudley, has been called, in honour of its principal founder, the *Dudley Observatory*. The building, now complete, occupies a commanding position near the north-western edge of the city. It is spacious and well-arranged, and will be provided with instruments of superior excellence; among them, a heliometer of ten-inch object-glass, to be constructed by Spencer, the celebrated maker of microscopes.

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* In compiling this abstract, free use has been made of the notices which appeared at the time in the *New York Tribune*, *Daily Times*, and *Herald*, and the *Albany Evening Journal*. Where the notices seemed to have been furnished by the authors, they have generally been copied either entire or in part, after correcting typographical or other obvious errors. In most other cases the meagre, and often erroneous, abstracts of reporters have been used as the basis of brief sketches, which, however incomplete, will, it is hoped, be found to involve no positive mis-statements of the facts or opinions of the authors. In this abstract no mention is made of such papers as have thus far appeared only by their titles, and several others have been omitted on account of their purely local interest, or from the difficulty of procuring a satisfactory abstract.

SECTION OF MATHEMATICS, PHYSICS, AND CHEMISTRY.

The Elements of Potential Arithmetic. By Prof. BENJAMIN PEIRCE. —Potential Physic investigates what kind of a world human intellect, having reached its highest point, would construct in respect to the distribution of power? If it be proved that it would construct one similar to that we inhabit, it indicates that the world was created by an intellect to which ours is in nature similar.

Potential arithmetic pursues this problem so far as regards numbers. By his combination of numbers Pythagoras was able to form his ideal "Man" in physical proportion true to nature, though differing from any actual type of living man. One combination and proportion of his numbers would give the Apollo, another the Venus, another a lower type than either, and another a lower type still. The order and principles which governed his arrangement would seem to indicate that a fixed law of number governed the structure of man. Architecture, by the Pythagoreans, was shown to be also based on a fixed law of number. Hence, number they considered the chief principle of the Universe. One designated the Creator or Unity. Four indicated development. Oriental philosophers also have fanciful theories respecting number. Odd numbers they term masculine, even numbers feminine.

A law of constantly recurring numbers or definite proportions may be traced in the planets, in their motion, in their bulk, density, &c. So also a law of definite proportions, and also of definite arrangement, is traceable in the chemical combinations which make up natural substances. In the organic world, the changes correspond to the change of numbers, by addition, multiplication, square and cube root, and proportion.

Professor Peirce endeavoured to show that by the combination of the simple primary ideas of number, and of the consciousness of power, we should be led to laws similar to or identical with the laws of both organic and inorganic chemistry, and also to those of alternate generation in zoology; and furthermore, that views of the negative unit and imaginaries could be obtained in this mode precisely similar to those developed in Sir William Rowon Hamilton's purely formal or formalistic discussion of those subjects.

On the Next Appearance of the Periodical Comet of Thirteen Years. By Dr PETERS.—This comet was discovered by Dr Peters at Naples in 1846. He has prepared an ephemeris of the comet from 1857 to 1860, and made an exposition of the methods of observation. It was a comet very difficult to discover. It was necessary to observe it with the eye in perfect darkness, and the time required for an observation is five minutes. In order to facilitate the observations, he has prepared a series of lines, within which it should be found. Its probable orbit gives an ellipse of thirteen years, with a probable error of one year, so that its period might be twelve or fourteen years. In 1853 or 1854 Saturn came into nearly the same position as this comet, and some uncertainty exists as to its distance, it having been difficult to ascertain whether it was nearer the interior or the exterior of that planet. The computation would have been easy but for the startling apprehension that some larger planet, like Saturn, would carry away the comet altogether, so that it would not reappear. Dr Peters, in announcing the result of his observations, remarked that it might seem to be of little use to have discovered a comet so difficult to observe, but he considered the addition of a new periodical comet a matter of the greatest importance, as increasing our knowledge of the space occupied by bodies belonging to the solar system. In his view, the discovery of a new comet was more important than the asteroids which have been discovered. He spoke of certain comets (among others, one described in an elaborate work by Dr Brunnow, of Ann Arbor), which have been diligently sought by astronomers in late years but not found, and alluded to the theory of the dissolution of comets in space—a theory to which one example appears to give support—the division into two parts of one of the comets discovered in 1846. That division still continues. Dr Peters recommended amateurs in science *to search for comets.* The professional astronomer has more earnest duties to perform, and cannot afford time for this search; but every periodical comet that is discovered is of use in determining the space occupied by the planets. The discovery of comets has decreased. Last year, not more than one or two were discovered. Dr Peters thinks this falling-off is owing partly to the fact that the award of a comet medal has been abandoned by the King of Denmark. For many years the discoverer of any telescopic comet received a comet-medal from the King, but in 1848 the custom was abolished, and the zeal for discovery has since declined. Dr Peters thought it would be a wise and useful measure to institute this medal anew. Amateurs in science would then be stimulated to make more researches. Amateurs have not that perfect interest in the subject which astronomers have, but the prospect of a public recompense would perhaps impel them to renewed industry. On the whole, Dr Peters concludes that the interest for science in Europe is decreasing, and in America increasing greatly, especially astronomical science. He hoped the institution of the comet-medal would be renewed here.

On Ammonia in the Atmosphere. By E. N. HORSFORD.—In this communication Professor Horsford stated, that in a former paper read at the New Haven meeting, he had been led into error by using, as an absorbent, asbestos which had not previously been freed from ammonia, and which therefore gave too large a result. On a re-examination of the problem, with new precautions and modifications, he had found from eight determinations, that a cubic metre contains from four to seven-tenths of a millegramme of ammonia.

On a Possible Modification of the methods of ascertaining the Density of the Earth. By STEPHEN ALEXANDER.—After adverting to the experiment of the plumb-line near a mountain, as liable to objections arising from the imperfect measurement of the density of the mountain and of the deflexion of the line, Professor Alexander proposed as a substitute to build up by the side of a plumb-bob, furnished with delicate spirit-levels, a mass of lead or iron in the form of a sphere, twenty-five or thirty feet in diameter, and to observe the change of the spirit-levels.

Dr Gould observed that this method was not equal to that of Cavendish, since the torsion balance is a more delicate test of minute forces, such as the attraction of the artificial mountain, than a spirit-level can be. He also repeated the suggestion of Weber, that the Gaussian mirror be used, by which a radius of unlimited length may be obtained.

Professor Bartlett thought there was a more fundamental objection to Professor Alexander's method; that the spirit-level would only show its own level surface, and that would be the resultant of the combined action of the earth and the artificial mountain.

Investigation and Calculation of the results of a General Process of Causation. By John Paterson.—This was an abstruse mathematical discussion, not capable of being made intelligible in a brief abstract.

On the Peculiar Atmospheric Appearance on 23d May last, at St Martin's, Canada East. By Charles Smallwood, M.D., LL.D.—The locality was nine miles from Montreal, latitude 45° 32′ N., longitude 73° 36′ W.; height above the sea-level, 118 feet. A peculiar haze was observed at noon, which had increased at 6.27 so as to obscure the sun completely. The wind died away to a calm; the colour of the haze changed from yellow to reddish, and then to a dark bluish tint. The thermometer marked a high temperature, and the Professor amused himself from six P.M. till dark in catching leaves and collecting ashes which were floating in the atmosphere, while the fowls went to roost and the frogs began to croak, and nature generally gave evidence that something had happened of an extraordinary character. The appearance of things was the more singular, from the fact that while this haze prevailed in the W.S.W., the horizon to the N.N.E. was perfectly cloudless. A similar phenomenon was noticed at Bytown, a long distance away. The cause was an extensive fire in the woods, some hundreds of miles distant. The haze appeared to have absorbed the white rays of the sun, but the calorific rays were not absorbed, the heat remaining oppressive during the whole period of obscuration. On the following morning (Saturday) there was a severe storm of thunder and lightning. Specimens of the leaves and ashes collected were exhibited. The ashes were black and exceedingly fine; the leaves appeared as if scorched; they were all caught before reaching the ground.

Professor Smallwood said the thunder-storm which followed the atmospheric phenomena was of an interesting nature, and proceeded to indicate its features; and as the subject of electricity was before the section, he mentioned his investigations of snow-crystals, the variable form of which he attributed to the electricity of the atmosphere.

On an Improvement in the Anemometer. By Charles Smallwood, M.D., LL.D.—This is a modification of previous instruments, which records, by a steel point on paper, the velocity of wind in miles per hour, and the times at which the velocity changes, at the same moment and by connected simple machinery recording the direction. It registers storms of seventy or eighty miles an hour, and gentle breezes of half a mile, and has been in use for twelve years without the need of repair.

On the Law of Human Mortality. By C. F. M'Coy.—In reading this paper Professor M'Coy illustrates his views by a curve in which the age is the abscissa, and the number living the ordinate. After pointing out the errors of the laws proposed by earlier inquirers he proposed a law of his own, by which the ratio of the number of the living to the dying is represented by one formula from the age of twenty upward. Although founded on an examination of the Northampton and Carlisle tables, it is found to agree very accurately (never varying one year's mortality) with all the tables to which he had had access, embracing the tables used in any of the standard works on life insurance.

Among the inferences that may be drawn from the law are the following:—

1. The rate of mortality invariably increases from youth to old age.
2. This rate is continually accelerated even in a higher ratio than in a geometrical progression.
3. In early manhood the rate does not differ much from a slow arithmetical progression.
4. There are no crises or climacterics at which the chances for life are stationary or improving.
5. There are no periods of slow and rapid increase succeeding each other, but one steady, invariable progress.
6. The law, though not the rate of mortality, is the same for city and country, for healthy and unhealthy places, for every age, and country, and locality; and this law is, that the differences of logarithms of the rates of mortality are in geometrical progression.

Analytical Discussion of the motion of a body under the action of central forces. By BENJAMIN PEIRCE.—This was a purely mathematical paper, taken partly from the author's quarto volume on Analytical Mechanics, now in the press. One point, incidentally brought in, is alone capable of being stated in general language. The discussion involved one of those interesting cases in which a single algebraic formula is suddenly discovered to embrace a great number of geometrical forms which, from all previous modes of investigations, had been supposed to be entirely disconnected with each other—a beautiful instance of science discovering the hidden harmonies of nature.

On Acoustics as applied to Public Buildings. By Professor HENRY.—After some remarks upon the true purposes of architecture, as an art which, in modern times, should regard the useful before the ornamental, although without excluding the latter, Professor Henry gave a sketch of the well-known acoustic laws applicable to the architecture of Public Halls. He then discussed the conditions producing echo and resonance. Under the latter head, he remarked that the material of the wall will affect the duration of a resonance. To test the nature of substances in this respect, a series of experiments was tried with a tuning-fork; first, to show that the motions excited by setting the fork on the back of a solid body are similar to those excited by the impulses of sound coming through the air against that body; and next, to discover what those motions are. A fork suspended by a cambric thread vibrated for 252 seconds, as was determined by holding under it a cavity which would resound in unison with the fork, and listening to it with an ear-trumpet. Placed on a thin pine board, the fork gave a loud sound, which continued less than ten seconds, the motive power of the fork being communicated to so large a mass of wood, and through that rapidly to the air. Placed on a slab of marble, the sound was feeble, but lasted 115 seconds. The fork was now placed

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upon a cube of India rubber lying on the marble slab. The sound was very feeble, but continued less than 40 seconds. The question, What became of the motive power in this case, as it produced so little sound? was answered by a set of experiments, proving that the sound was (so to speak) converted into heat. The amount of heat evolved in the rubber was so small as to be detected only by a delicate galvanemeter. Joule has, however, shown that the mechanical energy generated by a pound weight falling through 750 feet would, when converted into heat, elevate the temperature of a pound of water only one degree. On a brick wall the duration of the vibration was 88 seconds; on lath and plaster there was a louder sound, of only 18 seconds.

A series of different experiments was devised upon the reflection of sound. Parabolic mirrors were tested by lights placed in the focus, and a watch being substituted for the light, the reflected sound and the position of its focus examined by means of an ear-trumpet. Tissue-paper, flannel, and felt were introduced between the watch and the mirror, to try the effect of curtains upon sound.

Notes on the Progress made in the Coast-Survey, in Prediction Tables for the tides of the Coast of the United States. By A. D. Bache.—The following extract includes most of this paper, excepting the formulæ and tabular results:—

As soon as tidal observations had accumulated sufficiently to make the task a profitable one, I caused them to be treated, under my immediate direction, by the methods in most general use. The observations at Old Point Comfort, Virginia, were among the earliest used for this purpose, and the labours of Commander Charles H. Davis, U.S.N., then an assistant in the coast-survey, were directed to their reduction, chiefly by the graphical methods pointed out by Mr Whewell. This work was subsequently continued by Mr Lubbock's method, by Mr Henry Mitchell; and next the tides of Boston harbour were taken up, as affording certain advantages in the observations themselves, which could not be claimed for those of Old Point.

The system of Mr Lubbock is founded on the equilibrium theory; and in it the inequalities are sought by arranging the elements of the moon's and sun's motions, upon which they depend Having obtained the coefficient of the half-monthly inequality of the semi-diurnal tide at Boston, from seven years' observations, through the labours of the tidal division, and approximate corrections for the parallax and declination, I was much disappointed in attempting the verification by applying to individual tides for a year during which we had observations. There was a general agreement on the average, but a discrepancy in the single cases, which was very unsatisfactory. Nor were these discrepancies without law, as representing their residuals by curves did not fail to show. By introducing corrections for declination and parallax of the moon increasing and decreasing, we reduced these discrepancies, but still the results were not sufficient approximations. With the numerical reductions of the observations before referred to was commenced, in 1853, under my immediate direction, by Mr L. W. Meech, a study of the theory of the tides, directed chiefly to the works of Bernouilli, Laplace, Avery, Lubbock, and Whewell. The immediate object which I had in view was the application of the wave theory to the discussion of our observations. I thought that the mind of an expert mathematician, directed entirely to the theoretical portions of this work, with directions by a physicist, and full opportunities of verifying results by extended series of observations, the computations of which should be placed by others in any desired form, would give, probably, the best result in this combined physical and mathematical investigation.

The general form of the different functions expressing the tidal inequalities is the same in the different theories, and may be said, on the average, to be satisfactory as to the laws of change which these inequalities present. Whether we adopt, with Laplace, the idea that periodical forces produce periodical effects; or with Avery, that the tidal wave arrives by two or more canals; or with Bernouilli and Lubbock, the results of an equilibrium spheroid; or with Whewell, make a series of inequalities, semi-menstrual, parallax and declination, with different epochs, we arrive at the same general results, that the heights and times of high-water may be represented by certain functions, with indeterminate co-efficients, in the form of which the theories in a general way agree. By forming equations from the observations, and obtaining the numerical values of the coefficients by the method used so commonly in astronomical computations, the result is accomplished.

A general consideration of the coordinates in space of the moon and sun, without any special theory, would lead to the same result, representing the luni-tidal interval by a series of sines and cosines, with indeterminate coefficients.

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I present to the Association the tables computed by Mr Avery for applying this method to the prediction of the tides at Boston harbour.

In order to test the coefficients, computations were made for different parts of the months of the year 1853, for which we have observations. Transit C was used as the transit of reference. The difference between the predicted and observed results are shown in a table, the first column of which contains the dates of the last, the observed less the computed result.

From this table it appears that in twenty pairs of tides, the morning and the afternoon being grouped to get rid of the diurnal inequality, there are two differences of less than 2^m, thirteen of more than 2^m, and less than 4^m, three of more than 4^m, and less than 10^m, two of more than 10^m. The probable error of the prediction of a single pair of tides is $4^h\ 12^m$.

These laborious researches are still in progress, but I have thought that the results already obtained required a notice of them and a recognition of the labours of Messrs Meech and Avery.

On the History and Theory of the instruments known as Rotascopes, Gyroscopes, &c. By W. B. Rogers.

On a New Method of Measuring celestial Arcs. By Alvan Clark.—Mr Clark described a new instrument invented by him for measuring the intervals of stars too distant to be brought into the field of view of a telescope. Within a year from the first thought of the instrument entering his mind, he had built a telescope of six inches aperture and 103 inches focal length, mounted it equatorially, governing its motion by Bond's spring-governor clock, provided the two eye-pieces, and as a substitute for a bifilar-micrometer, arranged a mode of using pieces of glass ruled with a ruling machine. Experiments had demonstrated the feasibility of using the two eye-pieces in this way, and of obtaining by them very accurate measures of the distances of stars, which are from three to one hundred minutes of space apart. The success of the instrument was, however, greatly due to the spring-governor, which keeps each star upon the wire accurately bisected.

On Various Cyclones or Typhoons of the North Pacific Ocean, with a chart showing their course of progression. By W. C. Redfield.—This memoir comprised notices of about thirty cyclones of violent character in the trade-wind latitudes of the North Pacific. As regards the several months of the year, their concurrence was as follows:—In February, one; April, one; May, two; June, two; July, three; August, four; September, four; October, six; November, four; December, one. At the Marian Islands, about latitude 13° N., they are looked for in December and January, as well as in the summer months. Various other cyclones in the more northern latitudes of the Pacific Ocean were also noticed in the communication. Some of these cyclones were well elucidated by dates afforded by the log-books, and reports of the United States Expedition to Japan, under Commodore Perry, who kindly placed them with Mr Redfield for examination and report. The route of one of these cyclones was brought under the notice of the last meeting at Providence; together with a few other traces on the manuscript chart. This chart, with large additions, is now engraved, and will soon be published. In this memoir Mr Redfield notices the relations of the cyclones to the monsoons, and the trade-winds of the Pacific; and he remarks also on the universality of the laws of cyclonic progression and action in the lower portion of the atmosphere, throughout all oceanic and geographic zones.

On the Modifications of Sesquioxide of Chromium. By E. N. Horsford.—In this paper Professor Horsford gave an account of a series of experiments on the modifications of sesquioxide of chromium, and other substances obtained principally from chrome-alum, illustrating his remarks by numerous specimens of crystals and solutions of brilliant colours. These results present many new instances of the atomic changes which may be produced by heat and other agencies without altering the chemical composition of bodies. A slight change of temperature produces a complete and permanent change of colour in the substance without changing its constituents. The conclusion of the author, from these researches, was, that these modifications were not in the sesquioxide of chromium itself, but in the compounds formed by it with water.

On the Relative Age of the different portions of the Moon's surface, and the catastrophe to which a large portion seems to have been subjected. By Stephen Alexander.—Professor Alexander remarked, that a map of the Eastern hemisphere, taken with the Bay of Bengal in the centre, would bear a striking resemblance to the face of the moon presented to us. The dark portions of the moon he considers to be continental elevations, as shown by measuring the average height of mountains above the dark and the light portions of the moon. He recently had seen the bearing of newly-observed phenomena on the question, the character of the ridges in the neighbourhood of Pico. These ridges are shown by their tints to be of the same geological character as the tops of the mountains. They show themselves to be recent disturbances or upheavals, by the manner in which they cross other formations, as though ejected through cracks in a previous crust. The superior thickness or elevation of crust in the dark portions is shown by the fact that some of these white lines running through everything in the bright portions, cease at the entrance into the darker regions. A close scrutiny of the white portions shows a great subsequent inundation of the white rock flowing over the ocean-beds (if that term be allowed) and raising their level. He thought that these facts threw some light on the inhabitants of the moon. Might not this flow into the ocean-bed have absorbed, by some chemical action (as water of crystallization or otherwise), the ocean and atmosphere. If so, the moon might have been formerly inhabited, and been rendered desolate by this change.

Mr Vaughan alluded to the want of atmosphere in the moon, and thought this showed that gases were not necessary to volcanic action. Nor could he believe that our volcanoes gave out any great amount of gases. If they did, the effect during so many ages would have accumulated, and shown itself in an analysis of the atmosphere.

Professor Mitchell inquired if Professor Alexander had paid special attention to the apparent lakes on the moon's surface; and described a lake about 13 miles long, with a mountainous bank upon one side and a beach upon the other, fed apparently by a river about 150 miles long, with two branches, several islands, and in one place tunneling a hill. He used such terms as though there were water there, because no other language could describe the appearances.

A Report on the New Methods of Observation now in use at the Cincinnati Observatory:—

1. New method of right ascension, as to its limit of accuracy.
2. New method of declination, as to its limit of accuracy.
3. New method of determining personal equation and personal error.
4. New method of determining instrumental errors.
5. New method of determining clock errors.
6. Observations on changes of figures of materials.

By O. M. Mitchell.

—Professor Mitchell commenced by observing, that if our observations in astronomy were only as accurate as the methods of calculation are perfect, we should obtain a marvellous power of astronomical prediction, and a marvellous power in the applications of astronomy. If we could only point a telescope, and tell *exactly* where it points, it would be all that we could require. His attention had therefore been directed to new methods of determining the position or direction of his telescope. The first point to be determined is to know with what accuracy he can determine the right ascension of a star—in other words, the exact moment of its passing the meridian. In order to do this, he attached to the rim of the revolving disc of his chronograph narrow strips of white paper at irregular distances. Close to the rim he placed a narrow bar, to hide or occult the strips as they pass. His assistant and himself then noted the times of their occultation, by means of the chronograph, and thus determined that they were able to estimate the instant of occultation with an accuracy that showed an uncertainty of only eighteen of the thousandths of a second. The Professor then went into a very minute, but very clear and intelligible account of his experiments to decide whether they could note the passage of stars over the wires of his telescope with as much accuracy as they could note the passage of these paper strips behind the bar. He and his assistant decided that they could note it with even more accuracy. Taking many observations upon various stars at unequal distances from each other, he had devised means by which he determined the probability of the errors arising from individual peculiarities in the observer's temperament or physical adaptation, and from the effects of variable and unsteady refraction in the atmosphere. Then he passed to the consideration of the errors which may arise from the irregularity of the motion of even the best clocks. There had heretofore been no method by which we could determine the absolute accuracy of the motion of the clock for short intervals of time—no way to determine whether a clock did not hasten for a few seconds, and then move a few seconds too slow, keeping on the average true time. He wished to devise a simple means by which he could determine, on the chronograph, the absolute rate of the clock for each second of time, and had made some partially successful essays toward it. Professor Mitchell then recurred to the subject of personal equation—that is, to the error arising from the imperfect working of human nervous organization. He had devised this plan of determining the personal equation: Under the little strips of paper on the rim of the chronograph he placed a metal point, which should, at the instant of passing the occulting bar, pass through a globule of mercury, completing the circuit, and making thus the strip of paper record, by the magnetic pen, its own occultation with infallible and perfect accuracy. If, then, an observer note the passage with another magnetic pen, he has at once the mode of determining his personal equation or personal accuracy. Passing next to errors of levelling, Professor Mitchell described a mode by which, through the means of cups of mercury placed on each pier of the transit instrument, connected by a tube of mercury, he can at each moment of observation determine the level error of the axis of his transit. This will also give him the means of a perpetual determination of his azimuth error, and collimation. Passing next to modes of determining declination or polar distance, Professor Mitchell spoke of the value of the micrometer screw, and gave an account of his experiments, by which he demonstrated the practical liability to error involved in measurements dependent upon a screw, and which had led him to the conclusion that he would henceforth never rely upon micrometric measurement. He must have more perfect instruments. An attempt had been made to make such an instrument; it had been in use in his observatory, and he would now present to the Section some of the results. These results show that his present instrument gave him the means of recording the right ascension and declination of each star of a group, at one single passage of the group over the meridian, with an accuracy unsurpassed, nay unequalled, in the working of any observatory. After mentioning these results, the Professor described the simple machinery of the instrument, by which he gives a mechanical multiplication to the motion of the great telescope, so that the motion of a needle over a graduated arc gives the means of reading, by the naked eye, the motion of the telescope to the tenth of a second of arc. He detailed the careful experiments by which he proved that the needle was absolutely and invariably obedient to the motion of the telescope. He had also the best witness to the accuracy of the machinery in the delicacy of his astronomical results. A double star, for example, of the ninth magnitude, the components being of equal size, about 15″ apart, but differing only nine-tenths of a second in declination. This pair having often been observed on different nights, it occurred to him to make a comparison of the differences on different nights, and he found to his delight that none of the observations differed one-tenth of a second of arc from the mean of nine-tenths. No micrometric work of any observatory is supposed to give such results. Professor Mitchell closed by an account of many delicate experiments to show the changes of figure produced by the changes of temperature, moisture, &c., in the air surrounding the instruments.

Further Investigation relative to the form, the magnitude, the mass, and the orbit of the Asteroid Planets. By Stephen Alexander.—Professor S. Alexander went into a discussion of the form, the magnitude, the mass, and the orbit of the planet by whose rupture he supposed the asteroids were formed. He had attempted to discover the physical characteristics of this planet and its ancient motions by a variety of independent paths, and was led by every path to similar results, namely, that the old planet revolved about the sun in about 1732 days, rotating in three and one-third of our days, and having a diameter about nine times that of the earth, but being excessively flattened at the poles. The orbit of his supposed planet he also shows was very nearly circular. In some of his investigations he had made great use of the remarkable analogy first discovered by Mr Kirkwood and presented to the Association at the Cambridge meeting.

Professor Peirce made a remark on the industry of Professor Alexander, and the remarkable coincidence, to say the least, which he had brought to light. He then observed that the analogy between the ring of Saturn and the belt of the asteroids was worthy of notice. It was to be remembered, that in order to have Saturn's ring remain continuous and flattened into so thin a sheet, the radial or vertical tide in the ring produced by the satellites must be neither too large nor too small. But if the solar system were formed according to the nebular hypothesis, the tides in the remaining mass, after the formation of Jupiter, must have been, from his great size, extraordinarily great, and have produced a different sort of ring at the distance of the asteroids from those produced for the other planets.

Mr Vaughan observed that the orbits of interior planets would render those of exterior ones circular, as grinding a stopper in the neck of a jar rendered it circular.

On the Heat on the Sun's Rays. By Elisha Foote.

On the Heat on the Sun's Rays. By Mrs Elisha Foote. Read by Professor Henry.—These papers described experiments from which it was inferred, that the heating power of the sun's rays varies with the temperature of the place into which the rays fall, that the temperature of air is raised by sunshine passing through it, that in the same condition rarified air is less heated than that which is condensed, moist air more than dry, carbonic acid gas more than atmospheric air, and oxygen more than hydrogen gas.

Approximate cotidal lines of diurnal and semidiurnal tides of the Coast of the United States on the Gulf of Mexico. By A. D. BACHE.—The paper was communicated by authority of the Treasury Department. It is supplementary to those on cotidal lines of the Atlantic and Pacific coasts heretofore communicated to the Association. Preparation was made at the last meeting for these conclusions, by presenting the type curves of the Gulf Coast. The tides from Cape Florida to St George's are of the usual type, with a large daily inequality. From St George's to the mouth of the Mississippi, they are of the single day type. Then the half-day tides reappear to extend beyond Galvestown, the day tides recurring at Aransas in Texas, and southward. When the type curves were presented, the mode of decomposing them into a diurnal and semidiurnal wave was described.

The tide stations extend along our whole coast, but observations are much wanted beyond it, to complete the investigation, on the south side of the straits of Florida, on the eastern coast of the Gulf of Mexico south of Texas, and especially between Cuba and Yucatan at the entrance of the Gulf from the Carribean Sea. A table of the stations at which the observations were made of the heights of tide (rise and fall) observed, and of the half-day and day tides was given; and another, showing the period of observation and the name of the observer. The first table is represented on a diagram, by which a navigator may find the rise and fall of the tide approximately on any part of our Gulf coast. The least observed rise and fall is at Brazos Santiago, Texas, and is nine-tenths of a foot. The greatest is at Cedar Keys, Florida, and is two and a half feet. The difficulties of the problem presented by these tides are explained,—removable in part by the progress of the survey in the Gulf; inherent in them in part.

A diagram shows the general form of the curve of interval between the moon's transit and high water. Advantage is taken of part of the curve which changes but little in ordinate, to obtain an average lunitidal interval, corresponding in kind with the number for semi-diurnal tides.

These tides occur about the period of greatest declination of the moon. These intervals at greatest declination vary greatly during the year; and the form of curve showing the annual change, is presented as deduced from observations at Key West, Fort Morgan (Mobile entrance), and Galveston, as well as from San Francisco on the western coast, where the results are remarkably regular.

In comprising the two sets of cotidal lines for the diurnal and semidiurnal waves, we find a general resemblance in the great bay between the western coast of Florida and the eastern coast of Louisiana.

Supplement to the Paper published in the Providence Proceedings, on the secular variation in magnetic declination in the Atlantic and Gulf Coast of the United States, from observations in the 17th, 18th, and 19th centuries, under permission of the Superintendent. By CHARLES A. SCHOTT.—In a paper communicated to the Association at the Providence meeting, the secular change of the magnetic declination was investigated by Mr Schott. In the course of last summer he made some additional observations by direction of the Superintendent of the Coast Survey, and in the paper now presented the results are combined with those previously obtained. The former deductions have gained considerably in accuracy and have received important additions. The number of stations is increased from ten to thirteen. The recent observations appear to show a slight diminution in the rate of increase of westerly declination, leading to the supposition that the inflection in the curve representing the secular variation corresponds to about 1850. All the observations concur in placing the minimum about 1800. The present rate of increase of westerly declination is about five minutes annually along the Atlantic coast.

Discussion of the Secular variation of magnetic inclination in the North-eastern States, communicated under permission of the Superintendent and authority of the Treasury department. By CHARLES A. SCHOTT.—The results are confined to the limits of 38° and 41° of north latitude, there being too few observations in the southern part of the United States to permit safe inferences there. The element of magnetic dip, though less important practically than that of declination, is of value in navigation in certain latitudes, and from its connection through Gauss' investigations with the declination and intensity, assumes a high degree of importance. Where the declination observations on this coast go back to the seventeenth century, the dip has only been accurately observed for 23 years; for the earliest observations made in 1782 were, from the imperfection of the instruments, of little value. During this period the dip has decreased, reached a minimum, and began again to increase; so that it has been a highly interesting period for observation. The lines of equal dip have been deduced by Professor Loomis, with his usual ability, from the observations which had accumulated before the date of his paper. The present memoir includes additional results, and discusses 161 observations made at the different stations between Toronto on the north, and Baltimore on the south. The same modes of discussion were adopted as in Mr Schott's former paper, and the results at each station are separately discussed, and the computed result compared in tables with the observed. The average probable error of the results at any one station is about one minute and six-tenths of dip, and the time of minimum dip is ascertained to be about two years and seven-tenths. This time was the year 1843, or rather the close of 1842 (1842·7.) Mr Schott points out why these results do not agree with Professor Hansteen's, who had not observations enough to determine the epoch of minimum depth with accuracy. Observations on the Western coast confirm these results for the Eastern.

Remarks on Ozone.—Observations by Professor WILLIAM B. ROGERS.—Professor Rogers said that the chief object in this communication was to call the attention of American observers to a branch of inquiry which as yet they had greatly neglected, and to indicate a change in the methods of observation, which he thought essential to make the effects on the ozonometer a fair measure of the quantities of ozone in the atmosphere. He had hoped, also, to elicit from Dr Smallwood of Montreal some of the results of his long experience in this class of observations, but was deprived of the advantage by that gentleman's departure.

Professor Rogers presented the results of two short series of observations, the first of which were made in the City of Boston, at a station on the eastern side of the extensive Common, the second on a hill fifty miles westward of the city, at a height of about five hundred feet above tide, in the midst of an undulatory rural district, covered with verdure, and removed from any collection of houses or manufactories. The ozonometer used was the ordinary test paper of Schoenbein, which was exposed freely to the outer air in such a way as to be sheltered from strong light and from rain.

The city observations extended from the 1st of February to the 31st of May. In these it was found that winds coming from any of the eastern points gave little or no indication of ozone, but those from western points, especially from the N.W., produced a strong impression upon the test paper. Thus for the four months of observations in the city, the mean for east winds was 0·6, that for west winds was 3·9, the former showing no trace of ozone unless when the current was very strong.

At the country station, the observations, extending from the 1st of June until late in August, when the report was drawn up, furnished very different results. Here the air, from whatever point it arrived, was more or less ozonized, rarely showing a less amount than that corresponding to 5 on Schoenbein's scale, often attaining 9, and occasionally even reaching the maximum, or 10. In only a single instance throughout the summer was there an entire absence of effect. In this series the mean for east winds was somewhat greater than that for the opposite currents. The former was 7·6, and the latter 6·7 of Schoenbein's scale.

The almost entire absence of ozone in east winds at the Boston station, and its presence in those from W. and N.W, Professor Roger ascribed to the circumstance that the former, in order to reach the place of observation, had to traverse a wide extent of the densely built city, while those coming from westerly points reached the common with but little intermixture of air from streets or buildings.

In all these observations it was remarked, as a general result, that the effect on the test, both as to rapidity and amount, was somewhat *in propo. tion to the velocity of the moving air.* Numerous instances were noted of a light breeze continuing for several hours with but a small impression on the paper, while the strong wind which followed from the same quarter produced in a single hour the most marked effect. Indeed, in very gusty days the impression was so quickly made and so strong, as to render necessary the renewal of the test paper several times within the twelve hours.

This increase of ozonic effect with the velocity of the wind Professor Roger considered to be mainly due to the larger amount of air brought in contact with the test in a given time. In this view the fact becomes very important, as showing the great imperfection of the common mode of observation, even for purposes of rude comparison, since in observing successfully in a calm and in a high wind, we are in fact *comparing the amount of ozone in vastly different quantities of air.* To avoid this error, some means should be adopted for furnishing to the test equal quantities of air in equal times. Such a result would be secured by an aspirating apparatus having a small chamber in the path of the current to receive the test. Such an arrangement, capable of bringing into action a large volume of air in a short time, would doubtless detect ozone in a multitude of cases where the common observation in calm air would show none. It would also enable us to make hourly, or even half-hourly observations, instead of waiting for the slow development of the action through half a day, a process which, instead of summing up the ozone actions of the twelve hours, allows the effect of one period to be more or less obliterated by that which follows.

Tidal Currents of Saturn's Ring. By BENJAMIN PEIRCE.—Professor Peirce, in commencing his remarks upon the tides of Saturn, observed that this subject was apparently of small importance, even in regard to Saturn's own system. But a knowledge of this subject must lead to a thorough revision of all that has been done upon the subject of the constitution of Saturn's rings. The tides of the ring are therefore important to be considered. Briefly alluding to the main points of the previous discussions, and giving credit to Laplace for a paper on the subject which appeared lately to have been forgotten, he called upon the physicists of the section to listen carefully, and criticise freely the physical assumptions which he should be obliged to take as the basis of his calculations. The Professor then proceeded to discuss his abstruse problem, illustrating the question by means of the brim of a hat, and telling the audience to remember that the ring of Saturn itself was thinner in proportion to its size than the hat brim, the thickness being only one-thousandth of its breadth.

The paper itself was a deeply interesting one to those familiar with mathematical and physical inquiries, but was too technical to admit of a report. The interesting points in the theory of Saturn's ring, to the general reader, are that the ring is fluid, and that it is held up from collision with the planet by the action of the satellites. These points have been announced before, but Professor Peirce, in the present paper, had given a much fuller and more complete investigation of the whole phenomena, as well as of the theory of the subject.

On the Meridian Instruments of the Dudley Observatory. By A. GOULD.—The meridian circle and transit instrument have been ordered from Messrs Pistor and Martin's in Berlin, Prussia, the makers of the beautiful instrument ordered by Chancellor Tappan, recently erected at Ann Arbor, Michigan, and placed under the care of Dr Brunnow. The instruments are to be somewhat of an eclectic construction. There are two types of astronomical instruments—the English and the German. The English are massive, stable, built with the hope of preventing errors in the position of the main parts; while the German are light, airy, artistic, built for ease of handling, and for accurate measurement of the minuter movements. The one is the instrument of an engineer, the other that of an artist. Dr Gould proceeded to describe the modifications which he had with difficulty induced the German builders to introduce into these instruments. The telescope of the meridian circle was to be of seven and a half inches aperture and ten feet focal. The glasses are from the Messrs Chance of Birmingham, and Dr Gould had wished to have them ground and figured by the excellent artists of our own country, who have so well proved their ability to give unsurpassed accuracy to large object-glasses; but his German friends proved sensitive, and insisted upon either doing the whole work or none, and he therefore had allowed them to figure the glasses, with the proviso that they should be carefully examined and compared with the best American, and the result, whatever it was, should be made public. The eye-pieces are to have both a vertical and horizontal motion, and the diaphragm to be provided with both a vertical and horizontal micrometer. The chronograph was to be used, but in the case of the polar stars the slow motion requires the adoption of a system of micrometric measurement recently introduced into the Imperial Observatory in Paris, by Leverrier. It had been decided to use Challis's arrangement of collimators, instead of the convertibility of the object, and eye-piece, and of the telescope, for the purpose of testing the figure of the tube. Dr Gould would not take up the time of the section in discussing this matter at length, but there was one opinion of his which he would advance, namely, that he did not conceive the flexure of the telescope to be a minimum in zenith observations, nor a maximum at the horizon. The circles are divided to two minutes, and are read by microscopes to the tenths of a second. The illumination of the field of the Ann Arbor instrument was regulated by a set of plates somewhat like those which on a large scale regulated the swell of an organ. A method of observing bright stars has been introduced in the new circle, by which both the threads and the field may be illuminated, but with complementary colours. Dr Gould described the means which had been arranged for determining every instrumental error by two entirely independent methods.

On Some Special Arrangements of the Solar System, which seem to confirm the nebular hypothesis. By STEPHEN ALEXANDER.—After some remarks to show that this hypothesis cannot justly be charged with an atheistic tendency, Prof. Alexander presented the various proofs of the actual existence of nebulous matter. While many nebulæ, so called, had been resolved, others had not; and the comets, the zodiacal light, and eclipses displayed matter of this kind which, of course, was not thus resolvable. After discussing the densities and distances of the planets, he explained the process of formation of solid planetary bodies by the breaking of gyrating nebulous rings. He showed that the planets, as now situated, mark the centres of gyration respectively of the rings from which they were formed. Neptune was thrown off by itself; there was one ring for Uranus, a double ring for Jupiter and Saturn, and a double one for Mars and the asteroids, and so on.

Professor PEIRCE remarked that, according to the nebular hypothesis, there should be at first but little eccentricity, and in nature Neptune has scarce any. But Neptune would produce a slight perturbation in the next ring, and Uranus would have, as it has, a slightly more eccentric orbit. When we came to Jupiter, his immense mass would produce tidal currents in the next ring of an extraordinary character, and we have there the group of asteroids with their eccentric orbits. Mars, being smaller, would perturb the earth's ring but little, and the earth has a small eccentricity. But again, Venus, being so large in proportion to Mercury, would give that body the highly eccentric orbit it has.

Discussion of the terrestrial magnetic elements for the United States, from observations in the Coast Survey and others. A. D. BACHE and J. E. HILGARD.—The magnetic observations made in connection with the Survey were scattered, at 160 different stations, along the entire sea-coast, and the data were reduced to the common period of the year 1850. The line of no variation, or that passing through all the places where the magnetic needle points to the true north, intersects the coast near Ocracoke, between Cape Hatteras and Cape Fear, in a N.N.W. direction, curving gradually to the north, and passing through the middle of Lake Erie.

To the north and east of this line the declination (or variation of the compass) is to the west of north, being 6° near New York, 10 near Boston, and 16° in the eastern part of Maine. To the south and west of the line of no variation it is east of north, being 8° east along a line running directly south a little to the west of St Louis and New Orleans, 13 near San Diego, and 21° near Cape Flattery, on the western coast. A map of this kind is of great practical value to surveyors. The dip of the needle varies from 75° in the north-eastern States to 60 along the northern shore of the Gulf of Mexico, and the horizontal force from 3·5 to 6·0 in the same regions. Mr Hilgard proceeded to institute a comparison with former maps, by Colonel Sabine and Professor Loomis, showing the progress made, and also with the magnetic charts by Gauss. The paper closed with a general table comparing the observations with the map, showing discrepancies and local deviations.

An Account of a large Barometer in the Hall of the Smithsonian Institution. By JOSEPH HENRY.—Attempts have several times been made to form barometers of water instead of mercury. One was by Professor Daniell, in the hall of the Royal Society, in which a glass tube was employed, filled with boiled water while in a boiling state; the lower surface of the water was covered with castor oil, to prevent contact with the air, but this precaution was found not to be sufficient. Air was absorbed by the oil, and the nitrogen of this air absorbed by the water. Another attempt was made to exclude the air by a thin film of gutta percha left after the evaporation of naphtha. But a valid objection to water arises from the vapour which will fill the top of the tube. Professor Henry had decided to use sulphuric acid which does not give off any appreciable vapour, nor absorb any air. The objections to its use are the liability to accident, and its affinity for water. But care can guard against accident, and the moisture can be absorbed from the air which touches it by a drying-tube apparatus containing chloride of calcium. The construction was intrusted to Mr James Green of New York. The tube is two hundred and forty inches long, and three fourths of an inch in diameter, inclosed in a brass case, two and a half inches in diameter. The mechanical details of the instrument we need not repeat. The whole of the apparatus is inclosed in a glazed case, one foot square.

On a Method of determining the Latitude of a place, from the times when two known stars arrive at the same altitude. By W. H. CHAUVENET.—In this method the stars properly situated are supposed to arrive at the same altitude successively, and not simultaneously as in the method of Brown.

Tables of Prussian Mortality, interpolated for annual intervals of age; accompanied with formulæ and process for construction. By E. B. ELLIOTT.

Process for deducing accurate average duration of life, present values of life annuities, and other useful tables involving life contingencies, from returns of population and deaths, without the

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interpolation. By E. B. Elliott.—Mr. Elliott's labours upon the Prussian and other tables constitute part of a series of tables that are prepared, or being prepared, at the request of the New England Mutual Life Insurance Company of Boston, from official returns made to the English, Swedish, Prussian, and Belgian Governments, and from such reliable American statistics as can be obtained. In several of the United States, while the returns of the living are sufficiently trustworthy, those of the numbers dying are sadly deficient. The present Secretary of State in Massachusetts has consented to a change in the registration report for 1855, which will afford better material for the satisfactory construction of a life-table for the larger part of the population of that commonwealth. Mr Elliott briefly indicated the nature of the table presented, and the formula and process for construction. He described the more common methods of calculating life tables, and contrasted them with improved methods of his own, illustrating the difference by diagrams, representing the intensity of mortality in various communities by curves. He discussed different methods for deducing from the ratio of the dying, within certain intervals of age, the probability that one living at the earlier age will attain the later, and indicated an accurate method for accomplishing that object, whether the deaths for the period be variable or uniformly distributed throughout the period. He also gave an abridged method for computing the average duration of life, life-annuities, and other useful tables, from population and mortality returns, which reduces the labour of weeks to hours, but giving results almost identical with those obtained by the tedious modes of interpolation in common use; the average duration of life, for example, calculated by the short method, seldom differing three weeks from that calculated by the usual mode.

Researches on the Ammonia-cobalt bases. By Dr Wolcott Gibbs and Dr F. A. Genth.—This paper presented the results of researches, carried on for several years past, to determine the nature of the bases formed by the union of ammonia with the sesquioxide and sesquichloride of cobalt. Dr Gibbs also referred to a series of compounds discovered by him, which, from their containing sulphurous acids, he had called Thiocobalt. These researches he considered as of high scientific interest, since they involve the combination of organic with inorganic bodies, and have thus an important bearing on medical and other branches of applied chemistry, as well as upon chemical theory in general. He alluded incidentally to the value of Chevreul's scales of colour, and Haidinger's dichroscopic laws.

Redetermination of the atomic weight of Lithium. By J. W. Mallet. This paper. beginning with an enumeration and criticism of the researches on the subject by Arfwedson, Vauquelin, Gmelin, Berzelius, &c., describes a process for preparing pure chloride of lithium from the crystallized spodumene of Goshen, Massachusetts. This compound was then treated with nitrate of silver to determine its chlorine, and then its lithium. The result gave for the equivalent of lithium, 86·89, or on the hydrogen scale, 6·95.

(*To be Continued.*)

SCIENTIFIC INTELLIGENCE.

ZOOLOGY.

Dr Cleland on the Gubernaculum Testis.[*]

The following is a summary of the Mechanism of the Gubernaculum Testis, as detailed in the Prize Thesis submitted by Dr Cleland to the Medical Faculty of the University of Edinburgh, and now published.

Viewed from the peritoneal cavity, the earliest gubernacular structures are a peritoneal elevation passing on the surface of the Wolffian body from the lower end of the testicle to the junction of the epididymis and vas deferens, and a more marked continued elevation from the latter point to the groin. The former elevation shortens and disappears by the approach of the testicle to the extremity of the epididymis. The latter one is prolonged into a pit which forms round its inferior attachment, viz., the processus vaginalis. This elevation is the plica gubernatrix.

Similar structures are found in the female embryo, where the cornu uteri corresponds to the vas deferens, the Fallopian tube and its fimbriæ to the epididymis and coni vasculosi, and the corresponding elevation to that first mentioned is the rudiment of the ligament of the ovary, while its continuation is the round ligament at whose extremity is the canal of Nuck.

Viewed outside the peritoneal cavity, the first condition of the gubernaculum is as a cord, formed above from the external surface of the peritoneum, and perhaps some fibres issuing from the plica gubernatrix. This gives and receives fibres from the various layers of the abdominal wall, until it reaches its inferior attachment at the scrotum. As the processus vaginalis is formed, the fibres begin to be developed in two directions, some clinging to the processus vaginalis, and some following the direction of the gubernacular cord to the scrotum. As the process advances, the first set are the principal, and ultimately the only ones which are developed. Thus, is formed, a gradually thickening bulbous extremity, which pushes its way down the centre of the gubernacular cord; whose fibres, separated before it, form a kind of funnel-shaped cavity, and at last, when the processus vaginalis has reached the scrotum, are quite incorporated with the neighbouring tissues.

Fibres of the internal oblique muscle arch downwards in front of the gubernaculum, and from these the cremaster muscle is formed.

Other fibres ascend from the internal oblique muscle on the surface of the gubernaculum, but subsequently undergo atrophy.

The gubernacular cord also receives ascending and descending fibres from the aponeurosis of the external oblique muscle and from the fascia.

The gubernaculum consists altogether of two parts, a peritoneal process descending in advance of the testis, and a fusion of the layers of the abdominal wall.

The plica gubernatrix disappears by contraction, not by eversion.

The purpose of the descent of the Testes.—The descent of the testes to the scrotum is part of a contrivance, to which the peculiar nature of their vascular supply and the dense structure of the tunica albuginea give aid, by means of which an equilibrium of secretion and absorption is maintained, and the testes remain always full of fresh secretion, but not overflowing. The same peculiarities of structure, when the muscular tunics are contracted, cause the expulsion of secretion from the tubuli seminiferi.

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[*] Mr Curling has attracted Dr Cleland's attention to the circumstance, that he has referred to Mr Curling's latest paper,—that in the Cyclopædia of Anatomy and Physiology, and not to his original paper on the Gubernaculum, which appeared in 1841, and was therefore several years prior to that of M. Robin.

Serresius galeatus, Bonap.—Prince Bonaparte has described a new pigeon from the Marquesas Islands of a very remarkable form. The head, feet, and one wing, are all that have yet been received of this bird. Yet upon these the Prince founds a new genus in honour of his friend Professor Serres, the successor of Blainville and Cuvier. This species, to judge from the portions preserved, is only about one-third less than the Goura, and is allied to that group of fruit-eating pigeons known as the *Carpophagæ.* The bill measures 1½ inches in length, and the toes are longer than those of *Goura coronata;* but the remarkable part of its structure consists in the maxilla, as far as the bend at the tip being covered with a membrane clothed with thick scale-formed feathers. This membrane can, in life, be raised at will, in the form of a feathered caruncle.

Shark Oil.—The shark oil trade is of recent growth in North Greenland. It has lately extended as far north as Proven. At Neorhanek, the seat of the greatest yield, about 300 fish are taken annually. The oil is expressed from the liver of the arctic shark *S. borealis,* the Hvowcalder of the Icelanders; it is extremely pure, resisting cold, and well adapted for lubrication. It brings a higher price in the Copenhagen market than the best seal oils.—(Kane, *Arctic Explorations.*)

ZOOLOGICAL BIBLIOGRAPHY.

The Woolhope Naturalists' Field Club. Established 1851. Hereford, 1856. 8vo.—The first printed record of one of those very useful clubs which devote themselves to the investigation of local natural history. It contains the addresses of the Presidents, and a paper on the Ichthyology of Herefordshire by Hewett Wheatley, Esq.

Die Fossilen Mollusken des Tertiær-Beckens von Wien; unter der Mitwirkuny von Paul Partsch, bearbeitet. Von Dr M. Hörnes. Wien, 1856. 4to.—The third and concluding part of the univalves is completed, forming a volume entire in itself. German, with Latin specific characters, and illustrated by 52 lithographic plates of the greatest artistic excellence.

Finlands Mollusken. Beskrifne af A. E. Nordenskiöld, Licentiat, och A. E. Nylander Kandidat. Med. 7 plancher. Helsingfors, 1856. 8vo.—Appears to be a good guide to the land and fresh water mollusca of Finland. The letterpress is Danish, but the specific characters are given in Latin. The plates are mostly clear outlines.

Monographia Auriculaceorum viventium, sistens descriptiones systematicas et criticas omnium hujus familiæ generum et specierum hodie cognitarum, necnon fossilium enumeratione. Aucture Ludovico Pfeiffer, Dr Casselano. Cassellis, 1856. 8vo.—Written entirely in Latin. 242 species are described.

Die Tineen und Pterophoren der Schweiz. Von Prof. Heinrich Frey. Zurich, 1856. 8vo.—German, the specific characters written in Latin.

Die Kritischen Gruppen der Europäischen Clausilien. Von Adolf Schmidt. Leipzig, 1857. 4to.—German, with Latin specific characters; with lithographic plates, giving outlines of the shells; and enlarged finished figures, in various positions, of the mouth and other important parts of structure.

BOTANY.

On the Pines of Mammoth-Tree-Vale, Thirty Miles north of Sonora.—Colonel Fremont describes the largest red-wood measured by him to be 15 feet in diameter and 275 feet in height.

Mr Walter Hitchcock gives the following account of forest wonders which fell under his own observation. "One which had been felled was bored down with long augers, and took four men twenty-two days to get it down." The stump remains, 6 feet high; and its surface has been made level. "I measured it," from inside the bark across to inside the bark, "and it measured 25 feet; and is perfectly sound to the heart." Fifty-two feet in height of the bark in sections were taken to New York. At 166 feet from the ground the diameter is 10 feet; at 280 feet it is still 4 feet in diameter. At this point it had been broken across, and the remainder was much injured. But its height before it was felled "was set down at 300 feet."

"There are some larger ones blown down." One, evidently decayed before it fell, had been "in its fall broken off 60 feet from the roots. This part is hollow; and I cannot give you a better idea of its size than by telling you that I rode my horse through it from end to end." "But this is not the largest. There is another one blown down, which measures 110 feet in circumference (35 therefore in diameter) and 410 feet in length. This, too, is hollow."—(*Bartlett's Personal Narrative of Explorations and Incidents in Texas, New Mexico, California, &c., connected with the United States and Mexican Boundary Commission, during the years* 1850–1–2–3, vol. ii. p. 22, foot-note.)

Peruvian Bark-tree.—The trees yielding Peruvian bark, which grow at an elevation of 7000 to 8000 feet on the Andes, have for a long series of years been felled for the sake of their bark, and no pains was taken to replace them. Fears have naturally been entertained that, ere long, the supply of bark, and consequently of Quinine, would fail. Efforts have consequently been made to transplant the tree into countries where it is supposed the climate would be suitable. Dr Royle has taken measures for introducing Cinchona Calisaya or the yellow bark-tree into the higher regions of India; and of late years the Dutch Government have employed Mr Hasskarl to transport plants of various species of Cinchona from North America to Java and other parts of the Dutch East Indies. These attempts have been successful; and the reports, in regard to the growth of the plant, are such as to lead to the expectation that, ere long, the Peruvian bark-trees will be scattered over extensive districts, and will thus be saved from destruction.

Cuba Bast.—The source of this material, which has long been used for various horticultural purposes in this country, has been hitherto unknown. Sir William Hooker has been enabled, through the kindness of Henry Christy, Esq., to ascertain that the plant which yields this valuable fibrous substance is a Malvaceous plant, *Hibiscus elatus*, Sw., *Paritium elatum*, Rich.—a tree scarcely to be distinguished from *Paritium tiliaceum*, St Hil.

Garden at Bangalore, East Indies.—The Indian Government, at the suggestion of Dr Hugh C. Cleghorn, Professor of Botany, have resolved to establish a garden at Bangalore, so as to form a connecting link between the gardens at Madras and Ootacamund. The garden will be placed under the superintendence of Mr Jaffrey, who has been for some years in charge of the Agri-Horticultural Garden at Madras.* Mr Jaffrey was trained under Mr M'Nab, at the Botanic Garden of Edinburgh. The

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* Mr Jaffrey is now publishing an account of the Vegetables used in India.

Commissioner of Mysore has entered warmly into the arrangements, and will do all in his power to facilitate the formation of the garden and to ensure its success when established. The locality selected by Dr Cleghorn for the garden is Lall Bagh. It comprises rather more than forty acres, well situated, and sloping gently towards the north. The soil—judging from the crop of sugar-cane now in the ground, and from various other products—is generally good. The supply of water in ordinary seasons is abundant, and the tank at its upper extremity admits of easy enlargement, if this be found necessary. Water has been found near the surface at several places, and there are great facilities for irrigating the ground. The expense proposed is 300 rupees monthly, besides a grant, in the first instance, of 2000 rupees. As regards management, it is suggested that the garden superintendent, and every one connected with it, should be under the immediate and exclusive control of the Commissioner of Mysore. The great objects of the garden, Dr Cleghorn remarks, are the improvement of indigenous products, the introduction of exotics, the supply of them to the hills and plains, and the exhibition to the people of an improved system of cultivation in practical and successful operation. The climate is highly favourable, and the soil capable of producing the best description of many vegetable products. Bangalore is much better suited for agricultural and horticultural experiments than either Ootacamund or Madras, and, from its central position and intermediate elevation, the finer kinds of vegetables and better sorts of graft trees may be disseminated, with great success, to the neighbouring ranges of hills.—*Dr Cleghorn's Report to the Madras Government.*

BOTANICAL BIBLIOGRAPHY.

Loudon's Encyclopædia of Plants, comprising the specific character, description, culture, history, application in the arts, and every other desirable particular respecting all the plants indigenous to, or cultivated in, or introduced into Britain. New edition, corrected to the present time. Edited by Mrs Loudon, assisted by George Don, F.L.S., and David Wooster, late curator of the Ipswich Museum. This is truly a wonderful work, and displays in no ordinary degree the patient research of Mr Loudon. It extends to 1574 pages, and contains nearly 10,000 figures. It is a most valuable work for gardeners and horticulturists, and ought to be in every public botanical institution.

The First Part of the 14th volume of *De Candolle's Prodromus* has just been published. It contains Polygonaceæ by Meisner, with the suborder Eriogoneæ by Bentham, Myristicaceæ by Alphonse Decandolle, Proteaceæ by Meisner, Penæaceæ and Geissolomaceæ by Alphonse Decandolle. We are rejoiced to see that this important work is progressing, although it is still far from being complete. At the present rate of publication it promises to go on for another generation. When finished, the earlier volumes will undoubtedly require to be revised and reprinted, so as to bring them up to the state of science. The labour of such a work is enormous, and the mode in which it has been carried on reflects the highest credit on the Decandolles and their collaborateurs.

Flora Vectensis: being a Systematic Description of the Phænogamous or Flowering Plants and Ferns indigenous to the Isle of Wight, with a Botanico-topographical Map of the Island. By the late William Arnold Bromfield. Edited by Sir William Jackson Hooker and Dr Thomas Bell Salter. This work is the result of the careful observations of Dr Bromfield during many years. The editors give the following statement in the preface:—

"Dr Bromfield became resident at Ryde, in the Isle of Wight, in the year 1836, and shortly afterwards conceived the idea of preparing a Flora of the Island. He was not content to follow the usual practice in the making of local Floras and Faunas, and to be satisfied by presenting merely a tolerably full list; but he determined that the investigation should be very complete, and that every species should receive an original description. Nor was he satisfied with a mere cursory research in the framing of these descriptions, or with copying any character from other authors unverified by his own examinations. He was also equally careful to avoid describing general characters from individuals or varieties, and endeavoured, with immense and most persevering care, to select such points as are really the permanent and essential characters of genera and species. To ensure this result he was in the habit of obtaining a very great number of specimens of each species, collected from various localities; and, whenever practicable, he endeavoured to compare Isle of Wight specimens with those collected at a distance. Having thus secured sufficient material for investigation, his next aim was to consult every author within his reach for all the characters which different observers had noticed. For this part of his plans he had collected a very ample botanical library, especially of foreign authors. The characters, however, observed by others were, for his own descriptions, merely suggestive;—none being recorded but such as, after careful examination, he himself found to exist in nature.

"The results of these careful investigations were the most accurate and elaborate descriptions which can well be imagined; but such were the time and labour bestowed on each species—as much as many authors would give to a genus or family—that this circumstance very materially retarded the progress of the work. Unfortunately, also, when the Isle of Wight had been very thoroughly investigated as regards stations, and the work of describing was proceeding, the author enlarged his plan, and determined to comprise the whole county of Hampshire within the scope of his Flora. This certainly would greatly have added to the value of the work, had he been spared to complete it; but, such not having been permitted, it is impossible not to regret the interruption which the search for localities in this new field occasioned to the description of species. Another cause of interruption to the present work must also here be mentioned. Dr Bromfield had an intense love of travel, and this desire ever and anon prevailed, and occasioned a suspension of the Island Flora. Extensive tours through the islands of the West Indies, and through Canada and the States of North America, although they contributed most valuable information to the pages of the *London Journal of Botany*, very much impeded the progress of the present work. Finally, in 1850, Dr Bromfield started on an excursion to Egypt, Nubia, and Abyssinia; after which he was tempted to prolong his tour into Palestine and Syria, where, alas! he was cut off by fever at Damascus. Under these melancholy circumstances the manuscript of the unfinished Flora was committed to the editors by Dr Bromfield's nearest surviving relative."

The editors have bestowed much labour on the work, have done ample justice to the materials left by Dr Bromfield, and have produced a most useful Flora of the Isle of Wight.

Flora Indica.—We regret to learn that this valuable work is likely to be arrested in its progress, owing to the want of encouragement on the part of the East India Company. Drs Thomson and Hooker undertook the work at their own risk. The First Volume gives an earnest of what might have been expected at their hands. The authors are already well known to the scientific world by their botanical works, and every one acquainted with science is aware of their high standing and of their thorough competency for the task they have undertaken. The work is a national one, and promises to be one of the most important which has appeared in the botanical world. It will be the result, in a great measure, of personal observations, aided by the unrivalled resources of the Hookerian Herbarium. That such a boon to science should be stopped for want of funds, and that the authors should suffer pecuniary loss, is by no means creditable to our country. When the Admiralty have most nobly published the results of arctic and antarctic expeditions, it is surely not too much to expect that the East India Company, which is so much indebted to the labours of scientific men, should lend a helping hand in making known the vegetable productions of that vast territory over which they rule.

We think that all interested in science should unite in memorializing the Company on this subject, and we cannot for a moment doubt that the unanimous voice of scientific societies and scientific men will ultimately prevail.

Obituaries.—Christoph Friedrich Otto, late Director of the Royal Botanic Garden at Berlin, died on 7th September 1856. He was born 1st December 1783, and went to Berlin in 1801. He was employed first as a journeyman gardener, and afterwards, at the recommendation of Willdenow, was made Sub-Curator of the Royal Botanic Garden. In 1814 he was appointed Inspector of the Berlin Garden, and Director of the School for Young Gardeners. He received the fourth class of the order of the Red Eagle, in testimony of his services. He retired from his duties in 1843, on a pension of L.120. He published several botanical works, and he edited, in connection with Dr Albert Dietrieb, the "Allgemeine Gartenzeitung." A genus of umbelliferous plants is called *Ottoa*. His son is Sub-Inspector of the Botanic Garden at Hamburg.——Professor Tineo, Director of the Botanic Garden at Palermo, died in October 1856. He is succeeded as Director by M. Todaro, until the return of Professor Gussone from Ischia.

GEOLOGY.

Effects of Arctic Climate on recent Skeletons.—On the first of September, still following the ice-belt, we found that we were entering the recesses of another bay, but little smaller than that in which we had left our brig. The limestone walls ceased to overhang us. We reached a low fiord, and a glacier blocked our way across it. A succession of terraces, rising with symmetrical regularity, lost themselves in long parallel lines in the distance. They were of limestone shingle, and wet with the percolation of the melted ice of the glacier. Where the last of these terraced faces abutted upon the sea, it blended with the ice-foot, so as to make a frozen compound of rock and ice. Here lying, in a pasty silt, I found the skeleton of a musk ox. The head was united to the atlas, but the bones of the spine were separated about two inches apart, and conveyed the idea of a displacement produced rather by the sliding of the bed beneath than by a force from without. The paste, frozen so as to resemble limestone rock, had filled the costal cavity, and the ribs were beautifully polished. It was to the eye an imbedded fossil, ready for the museum of the collector. I am minute in detailing these appearances, for they connect themselves, in my mind, with the fossils of the Eischoltz cliffs and the Siberian alluvions. I was startled at the facility with which the siliceous limestone, under the alternate energies of frost and snow, had been incorporated with the organic remains. It had already begun to alter the structure of the bones, and in several instances the vertebræ were entirely enveloped in Travertin.—(*Kane's Arctic Explorations*, 1856.)

The space occupied by the Papers of Professors Wilson and Goodsir, and by the Report of the American Association, has prevented the Editors from inserting several important Original Communications, Reviews, and the usual Reports of the Edinburgh Societies. They regret that they have been compelled to postpone, till next number, Mr Blodget's Paper on the Distribution of Heat in the North American climate, with Map; Professor Bailey on the Origin of Greensand; Mr Baxter on the Influence of Magnetism over Chemical Action; Mr Murray on Insects transmitted from Quito by Professor Jameson; Mr Brodie on Corals of the Lias; Dr Davy on the Vendace, and several other Communications.

THE

EDINBURGH NEW

PHILOSOPHICAL JOURNAL.

Distribution of Heat in the North American Climate. By LORIN BLODGET, Washington. With a Map.

The basis of a discussion, of a more general character than any previously possible, in regard to the distribution of heat in the temperate latitudes of North America, has recently been furnished by the publication of the meteorological observations taken at the military posts of the United States. Though none of these posts have the rank of observatories, with the consequent accuracy of detail desirable for many purposes, the averages and mean results derived from them are still a very near approximation to averages derived from the most elaborate series; while among themselves they are sufficient for all purposes of general comparison. They furnish enough of positive data for conclusions on all the Pacific coast, particularly between the 32d and 50th parallels of north latitude; and this is the critical and important ground previously left quite obscure. It will be seen that this region, in its general expression and its singular anomalies, bears on the distribution of heat elsewhere, and is of unusual interest in itself.

The eastern border of the United States has been known, from various sources of observation, so long, that a reference to its basis of records is scarcely necessary; but those west of the Mississippi, only recently and for the first time collected, are mainly from military stations, and may here be enumerated for the several districts. All the records for the eastern

United States were, however, consolidated in the basis of the discussion referred to in this paper.

First, the eastern border of the great plains has a number of long-established military posts, with series of temperature observations for periods of from twelve to thirty years. From the south, they are in the following order:—Fort Jesup, in Louisiana; Forts Towson, Washita, Smith, and Gibson, in a group near the 35th parallel, longitude 95° west; Forts Scott, Learmonth, and Council Bluffs, on the plains near the 40th parallel; and Fort Snelling, at the 45th parallel. The results at the points first enumerated have been previously discussed on the basis afforded by five to ten years of observation; but for the report prepared by the writer on the army meteorological observations, twelve years' observations were added to each, bringing the results down to the close of 1854. Next to these, westward, are several posts, having three to six years of observation; which, with all the rest on the entire continent west of the 97th meridian, were first discussed in the report alluded to. Two or three of these are near Fort Snelling, extending the area of which that is the centre; next are three forts, for a year or two each; equally dividing the entire length of the Missouri River above Council Bluffs,—the last, Fort Benton, being at the foot of the Rocky Mountains; again, two posts, Forts Kearny and Laramie, dividing the distance to the mountains along the river Platte, and having observations for six years each; and for the last representative of the climate of the plains, Forts Atkinson, Arbuckle, and Union, occupying the same space on the Arkansas and Canadian rivers, in 35° to 37° north latitude.

Below this area of the plains, the posts are more numerous, and they may be grouped in the following order:—Fifteen being placed at the border of the high plains of Texas, about a central point, at 32° north latitude, and 98° west longitude, and having periods of observation from three to six years; eight posts in the vicinity of the Lower Rio Grande, of like periods of observation, and central at a point four degrees of latitude further south. In New Mexico, a group of seven posts in the vicinity of the Rio Grande, from the 32d to the 35th parallel, occurs, having the same periods of observation; and another of six posts, north of the 35th parallel, and at a much greater altitude above the sea than the first. Santa Fe, Fort Massachusetts, and Fort Defiance, are the principal of these.

Still westward, Fort Yuma represents the desert of the Lower Colorado of California, an isolated locality; and at or near the coast, Santiago, with two or three posts less permanent, represents a soft transition climate of vines and tropical fruits in southern California. Proceeding northward, the posts of the entire coast, from Point Conception to Astoria, are identical in climatological character,—Monterey, San Francisco, Bernicia, Fort Ross (Russian), Forts Humboldt, Orford, and Astoria. A group in the interior of California represents an isolated climate,—Forts Tejon, Miller, Reading, &c. Forts Vancouver and Steilacorm represent a partial interior district in Oregon; Forts Dallis, Owen, and Hall, Kooskooskia, and Great Salt Lake, represent positions still farther in the interior, and of considerable diversity of climatological character, but their periods of observation are short.

All the points here enumerated furnish new material of a uniform and comparable character; and all the observations, except those at Fort Ross, are for years since 1848. This comparability constitutes a great advantage; and a second advantage is found in the distribution of the posts in groups, so that the averages of groups and positions may be taken to obtain a perfected general expression. This last is an effective process for correction, when the details of observation may not be implicitly relied upon. All the observations were discussed in this synthetic manner in arranging and reducing the original observations for publication; and all the opportunities for elimination and correction which such a course afforded were seized at the time. In the ultimate preparation of the charts and illustrations this corrective process was continued.

In making up the basis for constructing a climatology including the two leading conditions, the Distribution of Heat, and the Distribution of Rain, the new material alluded to was found most valuable as completing the structure for which summaries had been before accumulated in the eastern United States, making an intelligible framework for that half, but wanting the western half to make up the continental whole.

In the eastern portion the whole mass of material was consulted, though the results at the military posts were alone quite ample. With the very valuable accumulations from scientific sources, it is believed that a better basis could hardly be employed for the illustration of the two leading conditions of the climate. The greatest difficulty arises from the fact of the most extensive scope given to the inquiry by the accumulation of material from so wide a field. It tends to give the discussion a cosmical character,—one too wide and general to permit accurate attention to details; and the details, both of observation and deduction, constantly require a reference to exterior general laws, in order to give the right place to the facts of observation.

The force of this remark is most apparent on reference to the features presented at the immediate coast of the Pacific, and to the measures of heat observed on the highest interior plateaus. In both cases, the facts of observation look incredible, and they must be illustrated and supported by analogies drawn from another continental area, or another coast similarly placed cosmically, to permit us to understand them fairly, and at last to receive them. It is not enough that the simple geographical positions are similar; an identity of atmospheric and maritime influences must exist, and, whatever these are, they must be judged by the aid of their parallels elsewhere, if they have any such parallels. There is no deep sea current refrigerating the western coast of Europe in temperate latitudes, by which the anomalous cold of the Pacific coast of the United States in summer may be illustrated; but we find its type on the Peruvian coast, in the cold waters observed by Humboldt; and the cosmical illustration gives us the parallel, therefore, when geographical position in the same hemisphere fails.

The next general anomaly is the great measure of heat at high altitudes of the interior; and to this there are, doubtless, parallels in the interior of Asia, in positions not geographically dissimilar. The simplest statement of this fact is, that from the 30th to the 45th parallels, on the wide Rocky Mountain plateau, *an altitude of four thousand feet counts nothing in reduction of temperature;* positions up to 4500 feet, in fact, usually giving averages equal to those at sea-level on either coast. The area so affected is nearly 20° of longitude in width, and the condition is thus one of the first magnitude in its relation to the climatology of these latitudes. This feature will again be referred to briefly; and it is cited here to show what problems are started by the simplest illustration of the observed facts of temperature in these new districts.

It must not be forgotten, in entering on the discussion of the distribution of heat here, that at the Atlantic coast we meet at once the converse of laws of position for the isothermals on the west coast of Europe. From the maximum of oceanic influences, the transition is abrupt to a coast in the immediate vicinity of the maximum of the antagonistic continental influences; and though the coast, softened by proximity to the sea, and by the influence of the gulf stream, gives softened local positions, and northward curvatures of the isothermals of the colder seasons, this influence disappears at a very short distance inland. From Georgia to Labrador the area is continental in its relations to heat, and it is only prevented from being the extreme area of this kind for the continent by the intervention of the great lakes, which throw the extreme district westward of their position at their latitude. Above and below them it is crowded eastward again to the immediate vicinity of the Atlantic coast.

The measure of depression for the isothermals of each season, in passing from the European to the American coast, need not be enlarged upon, as it is already very well known. It is greatest in winter and least in summer; and only in regard to the last season do the present results afford anything new. This new point is the assignment of a higher value to our summer temperature than before, and the development of what may be termed ultra-tropical temperatures in the southern part of the United States—averages as great as those of the arid transition belts of the south of Asia. A curving belt bordering the Gulf of Mexico, and from 3° to 5° of latitude in width, has averages higher than those of the tropical seas of the south; and there are large areas at some little distance from the coast possessing from 82° to 85° mean temperature for the three months. Above this, and in the Mississippi

Valley, as also on the great plains, the averages of summer heat are very high, and the isothermals, for that reason, exhibit extraordinary curvatures. They are repelled and turned southward at the great lakes, but they advance on the plains in the vicinity of the lakes much beyond the positions heretofore given them. The mean of 75° ascends the valley of the Missouri nearly to the 45th parallel, and this isothermal is bifurcated or expanded over a great area south of that river, where the plain rises above the river valley in its higher latitudes.

On all these plains, and in all the more considerable valleys, it has been the design to illustrate the *actual superficial distribution* in the isothermal charts, without correction or reduction for altitude in any case representing the general surface of the locality or district. The changes of altitude are so moderate, however, that few curvatures depend upon altitude alone, and most of the instances in which a line is thrust northward beyond the average of its position, are evidently due to strictly climatological causes—the expansion of a semitropical heat where surface favours it, and where positive causes do not prevent.

In the whole illustration it has also been found imperatively necessary to adhere to the surface conditions, as presented by the observations alone, and to undertake no reductions by the rules elsewhere found applicable to altitude, to obtain the equivalents at sea-level. On the irregular surface of Europe, with its abrupt elevations, and steep, moderately-elevated mountains, temperatures observed at any considerable altitudes must necessarily be corrected, even to represent the general surface. But here there are few such positions, and generally a high plain or plateau constitutes the general surface of an elevated district. In entering upon these, at whatever elevation, it is at once apparent that the rate of reduction for the altitude cannot be the same as in the case of a sharp single ascent from the sea-level; and that, if a reduction is attempted, new equivalents must be obtained for its scale. It is also unessential to more than one branch of even the most abstract discussion of the laws of distribution of temperature, and, as an indispensable preliminary to all discussion, the surface, or actual distribution, must first be known. This surface distribution must also be illustrated before one derived from it by corrections for altitude can safely be treated, as the results must be generalized, to permit verification of them in the first instance. It has been preferred to open none of the questions of vertical distribution in the present case, and to draw all the isothermals according to the actual conditions of the general surface of the several districts.

The citation of the several differences of vertical distribution actually found to exist is interesting in itself, as well as illustrative of the necessity of a rigid adherence to the rule of taking the facts of observation, without correction, for altitude. At the meridian of Fort Snelling, we find the plain rapidly attaining considerable altitude as we approach it from the east; yet for all seasons except winter, we find the isothermals rising in latitude as they are carried west, particularly above the 40th parallel, and continuing to do so to the foot of the Rocky Mountains. In the mean for the year, Fort Benton, and the vicinity of the Upper Missouri, at 2500 feet above the sea, are warmer than Fort Snelling, at less than half the altitude, and two degrees lower in latitude; and the first point is warmer also than the Atlantic coast at the same latitude. Fort Laramie, on the Upper Platte, and 4500 feet above the sea, presents the same anomaly, being slightly above the mean temperature of the Atlantic coast, and slightly below that of the Pacific coast, on the same parallel. The posts of Upper Texas generally exhibit a slight reduction of temperature when placed at from 900 to 1500 feet elevation, but not such a reduction as would be the equivalent of these altitudes in Europe. In the Rio Grande valley of New Mexico, posts at the average altitude of 4000 feet show temperatures equal to those at sea-level for the latitude; those at 5000 to 6000 feet are much reduced in temperature; and those at 8000 to 9000 feet are so much reduced as to show some decided correspondence to European rules. Thus, El Paso, at nearly 4000 feet above the sea, has nearly the same mean annual temperature as Charleston, which is in the same latitude. Albuquerque, at 5000 feet, most nearly corresponds with Baltimore, 4½° of latitude farther north; Santa Fe, at 7000 feet, with New York, 5° of latitude northward;

and Fort Massachusetts, at 8400 feet, with points on the Atlantic coast at the 45th parallel, a difference of position of 7½° of latitude. Comparing this point with Norfolk, in the same latitude, a difference of 18° 8′ in the mean annual temperature appears, or a degree for 445 feet of altitude nearly. At El Paso, a short distance southward, at Fort Laramie, not far northward of this position, and at Great Salt Lake, westward—each not far from 4000 feet above the sea—the reduction is not so much as a degree on the annual mean for 4000 feet of elevation. Under circumstances of so much diversity, it is easy to see that no rule can be employed until the entire surface has been observed or represented, and that the fullest comparison of actual observations, with the most careful generalization upon them, is necessary first to settle the facts of actual distribution, before any scale of reductions can be constructed.

The mountain ranges near the Pacific coast are everywhere sharp and high, yet their influence on the thermal condition is deemed less from their altitude simply, than from their obstruction of the atmospheric circulation. The coast itself is so peculiar as to present a greater source of diversity than that of altitude, and, consequently, even the high plains shut away from the sea have a higher temperature for this reason. The interior valleys of Oregon are warmer than the coast, though generally of considerable elevation. California has no high interior valleys, but the valleys it has exhibit excessive measures of heat when shut from the coast by mountain ranges. At great altitudes, this anomalous diversity becomes much modified, and it is doubtless ultimately sunk in the simple relations of vertical distribution alone; but, for the surface which we have to illustrate, and with which we have practically to deal, altitude has little of the significance in reducing temperature on the west slope of the United States which it has in the west of Europe.

It is obvious that the whole theory of vertical distribution of heat requires reconstruction, as applied to the surface of continental areas. There is no rule of uniform value or uniform adaptation, and the corrections required for surface observations, to remove whatever effect may belong to altitude, must be derived from a very thorough and complete collection of these observations themselves. It is probable that then the corrections will be absolute, and not proportional to the altitude; or that one plateau may require 10° of correction for altitude simply, and another 5°, and another no correction at all, though all may be four or five thousand feet high, and nearly alike in this respect. The *Coteaus* near the Upper Mississippi, at 2000 feet above the sea, reduce the temperature between 5° and 10° from elevation simply; the plain at Fort Kearny reduces it slightly at 3000 feet; that at Fort Laramie not at all for 4500 feet; the San Luis valley of New Mexico reduces it 10° or 15° for 8000 feet, &c. Such are instances of the diversity actually existing, where diversity could not have been anticipated. New and most interesting problems are presented by these facts of vertical distribution of heat, and the discussion of them must be reserved for the accumulation of observations from at least all representative positions.

The continental laws of distribution of heat at the surface are opened anew on this basis of American statistics, and the greatest difficulty is experienced in following it in the comprehensive manner which is enforced by the conditions of the subject. Anomalies are presented which may have their solution in facts disclosed in another hemisphere, and for the discussion of which the widest references must ultimately be made. Some of the apparent results may, however, be indicated with sufficient definiteness for the present purpose.

The most prominent point is the *general identity* of the distribution for the same latitudes of the two continents of the northern hemisphere, and the fact that the masses of these continents originate all the curvatures and peculiarities of position in the isothermal lines. In a word, if the continents were removed, all points having the same latitude would exhibit like conditions; and although this appears a plain proposition, needing no new assertion, yet, as here applied, it is intended to signify that the land masses cause uniform and symmetrical departure from the normal uniformity. It has been supposed that America was, to some extent, anomalous, and that it required or possessed a compensation in Europe; but these results give us a higher measure of heat in the south, in the interior, and on the north-west coasts of this continent, than has before been assigned to these districts. These additions bring it nearly up to the standard for the eastern continent, and for the difference that remains the vertical and outline configuration fully accounts.

The next great fact is the dependence,—subordination, it maybe termed,—of this distribution on atmospheric and oceanic circulation, and an outline configuration in relation to these. When we find the east and west coasts of the same continent, at the 50th parallel, differing as largely as England and Manchouria and Pekin first, and as Vancouver's Island and Labrador next, it is impossible not to admit the superiority of the only agents which can cause such results—the circulation of the atmosphere and of the sea's waters. The continental influences exerted in the accumulation of heat and in refrigeration, if exerted without modification, would of course be as decided near the western border of the continent as near the eastern;—why, then, are they excessive at the east in both cases, and very slight at the west, if the agents alluded to are not controlling for these latitudes?

The currents of the sea exhibit influences in the Pacific somewhat different from those known in the Atlantic; in the last the warm currents afford the most signal modifications, and in the first the cold currents stand out most conspicuously, as on the coasts of Peru and of California. In California, the facts shown by records at exposed positions on the coast are scarcely credible, without the support afforded by observations of air and water temperatures at sea; and it is obviously indispensable to connect the two in any intelligible notice of the thermal condition of the land areas. Had sea temperature been measured on the British coast, and traced through the belt of warm water which so greatly controls the climate of all the west of Europe, it would have been seen earlier that the west of Europe was largely exceptional in its measure of heat for the latitudes above 40° and 45°. The currents of the Pacific are still quite obscure, and the origin of this refrigerated mass, which has so great an influence in California, can scarcely be settled.

Behring's Straits are too shallow to send it forth, and the Peninsula of Alaska, and the Aleutian Islands, constitute a barrier which must be turned by a current originating in the great northern areas of the Pacific, where the Japan stream mainly wastes itself. Still there seems no source so likely to send this mass forth as the great sea east of Kamtschatka, from which the answering current of the Japan stream must come, if one is returned at all. All the volumes of warm water flowing to higher latitudes elsewhere have equivalents in cold returning masses, and this appears to be a case where such a mass is overlaid by warm waters through nearly its whole course, and appears at the surface only when lifted by the shelving coasts of California.

The two exterior causes, the winds and the sea currents, accord in their action in the higher latitudes of this continent on the west, but conflict below the 45th parallel in the warmer months, producing the greatest changes of thermal distribution through the successive months which are experienced anywhere. These contrasts give the isothermal lines positions which may seem fanciful, and which are difficult sometimes to define. They cannot be placed hypothetically; and if the number of observations is insufficient for a positive definition, they must be regarded as approximations only. They are now so in the interior of Oregon, and for portions of the coast toward Sitka, for portions of the Saskatchewan region, of the Upper Missouri plains, and for the Great Basin southward of Salt Lake. In the warm months the isothermals are compressed into a singularly narrow space, from Monterey, on the coast, to Fort Millar of the interior, and to all parts of the desert basin east of the Sierra Nevada. The higher portions of this basin region, on both sides of the Colorado river, but particularly on the east side, at Fort Defiance, are very much refrigerated in winter also.

In the charts prepared by the writer for his report on the United States military post observations, great care was taken to place the isothermals according to the best analogies afforded by a knowledge of the topography and surface conditions, in districts where observations were wanting, as in those above indicated. This topography is itself a new result, derived mainly from the recent surveys ordered by the United States for military purposes, and for a Pacific railroad. The vertical topography has been made as prominent upon the charts of illustration as could readily be done, because of its inseparable association with the thermal condition everywhere. The representation is still wanting in completeness in that respect, however, and vertical sections can alone answer the whole requirement.

Another point of interest in American distribution of heat, is the frequent institution of thermal areas of too high a temperature to connect even with tropical districts. The whole area, from the 35th parallel to the coast of the Gulf of Mexico, is such for the summer months, being from 5° to 10° above the mean temperature of the seas, and the Central American land areas to the southward, at that season. This excess culminates in the Rio Grande valley, where the mean of 85° for the three months of summer is attained. A mean of 82° to 83° embraces a large area, stretching across to Charleston, and all the excess above 80° belonging to this is, at least, so much above the measure for the tropical districts in these months.

Northward, on the plains, an area, having a mean of 75° for these months, is stretched over a large tract, from the plains near the Arkansas, at 2500 feet above the sea, to the Missouri River valley, at 1800 to 2000 feet, and extending up this last valley above the 45th parallel. The uniformity here is in part due to altitude; the plain declining northward, and the surface favouring accumulation of heat in the warm months, in a somewhat increasing degree, as we advance in that direction. A line is hardly adequate to the representation required here; an area tinted appropriately, and expanding from a line, to be again contracted to that form, would best illustrate the *actual climatological condition*, which alone can be given now.

In the desert valley of the Colorado of California, the district of greatest excess appears, and for the summer months this excess is far beyond the measure of heat on the west coast of Mexico, southward. The conditions observed at the Persian Gulf, and at the head of the Red Sea, are here reproduced, and the parallelism of the continents is fully shown in this as in other cases. How far this excess extends toward Great Salt Lake, it is impossible now to say, though, in a rigidly accurate illustration, a considerable area would appear to be surrounded by concentric isothermals, or by lines opening southward in a narrow neck along the Gulf of California.

In the San Joaquin and Sacramento valleys of California, the same concentric curve is again required for exhibiting the actual distribution of the climates. Both the coast and the plateaux of the Sierra Nevada differ extremely from the valley; and the segregation is nearly as abrupt at the south and at the north. Cultivable plateaux lie at the south at a great elevation; and as these decline toward San Diego and the coast, they are, on the whole, cool and equable, in contrast with the intense heats of the deep interior valley of San Joaquin. The modifying influences which exist everywhere, in greater or less degree, in configuration and altitude, appear to put on extreme phases in all these districts, and to produce anomalous and opposite results.

There are localities of a similar isolation, only in much less degree, in the valley of Lake Ontario, and in other portions of the north-eastern area of the United States, but they are of small extent. Generally, the high summer temperature, peculiar to the American climate, develops there readily at all points in the whole area under consideration; and in this respect it differs from Europe, though probably it departs less, or not at all, from Asia. It has Asiatic features in surface, character, configuration, and general climate, and decidedly so in this feature of thermal distribution.

The simple continental influences on this distribution of heat are worthy of a more extended notice than can be given them in this place. As said before, they are thrown near the eastern border of the continent, Labrador and the vicinity of Hudson's Bay exhibiting the highest degree of refrigeration known to those latitudes anywhere. But the lower latitudes, falling more particularly within the field of the present discussion, show an interruption of this line of maximum effect at the great lakes, softening the rigour of the winter cold, and thinning the line of minimum temperature at the west of Lake Superior, on the isothermals for the year. Notwithstanding the high summer temperature there, the excessive cold of winter throws the annual average below that for the cooler summer at various points of the same latitude eastward, and the greatest effect of continental refrigeration, as a single agency, is thrown out of the line it has at Hudson's Bay, and placed many degrees of longitude westward. The differences are small, however, and may be defined, in general terms, as the spreading of this line into a wide area, embracing the whole lake district, and affording several areas, signally marked by continental refrigeration.

Southward of the lakes, the maximum continental effect is again thrown eastward, and the line passes through Georgia and Florida for the months of winter, in which season alone it goes so far south in any relation to the atmospheric circulation. There is, indeed, but little difference between the plains of Opelonsas, in Western Louisiana, and the central districts of Florida, at the same latitude, in regard to the measure of winter depression, and the high plains of Texas institute an extreme measure of continental refrigeration in winter, which is expended before reaching as far east as New Orleans, and which is felt most decidedly near the Sabine River of Louisiana.

This last general feature of thermal distribution applies to the extremes, or dynamics, of this condition, as they may be called, as decidedly as to the averages, or constants. The sweep of changes, and the range of non-periodic variations of every degree, is greatest along this line of maximum continental refrigeration. The means for successive years show this strikingly, and the range of annual mean temperature, *which reaches* 12° on the high plains of Wisconsin and Minnesota, is highest on a line south-eastward from those points to Augusta, Georgia, Norfolk, and Charleston, At Norfolk and Augusta it has reached 10°; the coldest year being 5° below the average, and the warmest 5° above that average,—a range really of the most extraordinary character, compared with the range in the annual mean in Europe, and on the Pacific coasts generally. In the New England States it is much less, and much less for a large area southward, including Philadelphia.

Each of the general features of thermal distribution, briefly touched upon in this paper, has relations to subordinate features of unusual interest, of which those relating to range and non-periodic variation are the most important. The constants of daily and monthly curvature are scarcely less interesting, and perhaps of greater value ; and all the divisions in regard to annual averages, or to those for the seasons, imply and embrace new divisions of each of these classes. Thus, on the California coast, the horary or daily curve almost disappears for the summer months, and the curve among the months quite

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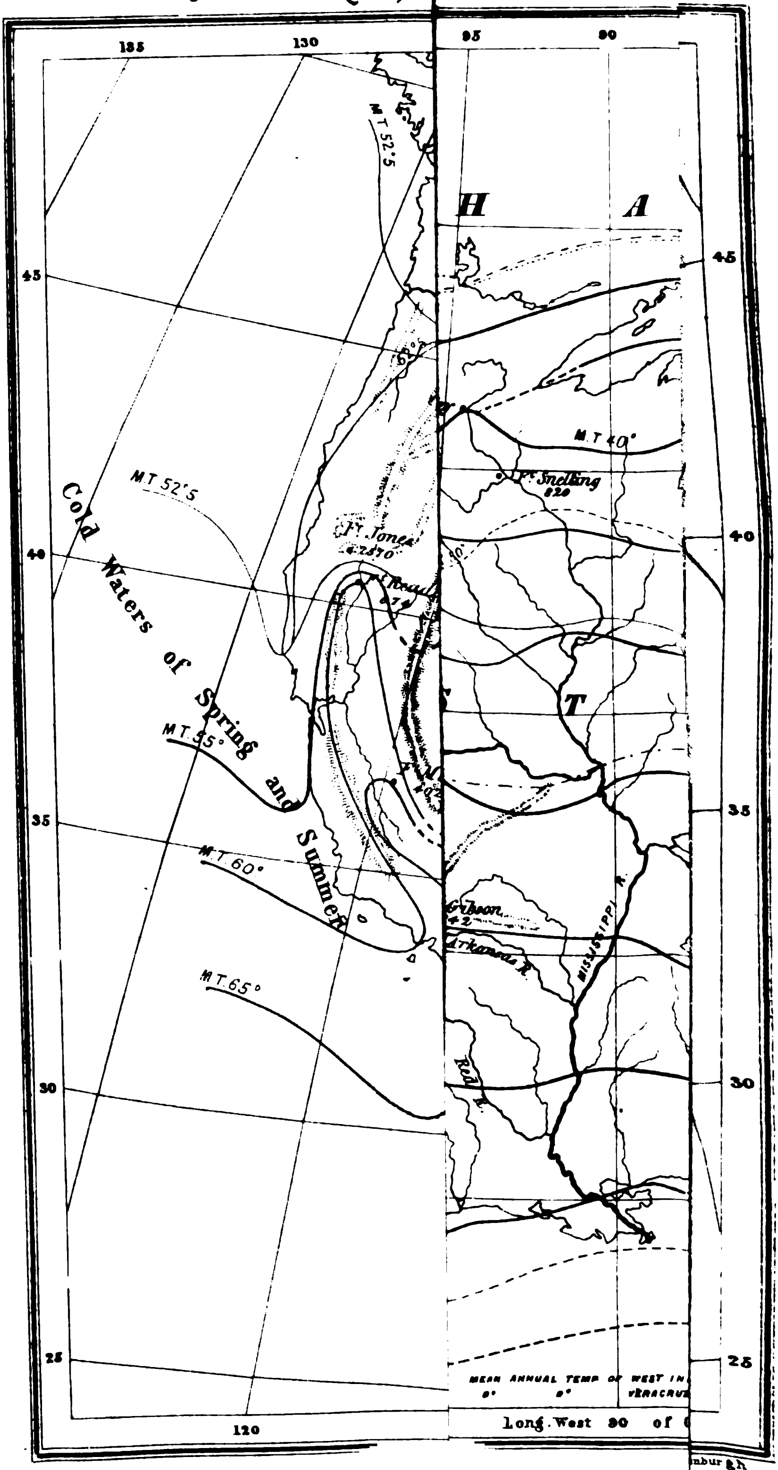
Plate 2 (?)


135
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Cold Waters of Spring and Summer
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M.T. 55°
M.T. 60°
M.T. 65°
M.T. 40°
Ft. Snelling
820
Ft. Jones
2570
Ft. Reading
Ft. Gibson
Arkansas R.
MISSISSIPPI R.
Red R.
MEAN ANNUAL TEMP OF WEST IN
VERACRUZ
Long. West 90 of
nburgh

disappears from May to October. In the interior valleys, before referred to as having excessive temperatures, both these curves are extremely sharp, passing through a great range.

It is obvious that the problems of thermal distribution require a more extended basis of facts than has heretofore been supposed necessary to their discussion, and *the temperate latitudes of the northern hemisphere* must at least be embraced in any discussion affecting large areas of either continent. It is, in truth, necessary to go still further, and to embrace the same latitudes of the opposite hemisphere.

The necessity of attention to oceanic circulation is enforced by American experience; for these currents, with the atmospheric circulation in the temperate latitudes, produce the most striking phenomena both here and in Europe.

The annexed Map exhibits the Course of the Isotherms for the Year; the following Table contains the results of some of the most interesting Stations:—

Mean Temperature of Stations on the Atlantic Coast,
Longitude 67° *to* 80° *W.*

Names of Stations.	Altitude in Feet.	Lat. N.	Mean Summer Temp.	Mean Winter.	Mean of Year.
		° '	° '	° '	° '
Hancock Barracks,	620	46·07	63·33	16·41	40·51
Fort Preble,	20	43·39	65·24	24·70	45·22
West Point, N. York,	167	41·23	71·33	29·69	50·73
Fort Washington,	60	38·43	77·77	37·36	57·87
Fort Monroe,	8	37·0	76.57	40·45	58·89
Fort Johnstone,	20	34·0	80·19	50·60	65·68
Fort Shannon,	25	29·34	80·56	57·18	69·64
Fort Myers,	50	26·38	82·41	65·36	75·04
Rocky Mountains and Plains of their Eastern Slope, Longitude 95° *to* 110° *W.*					
Fort Laramie,	4519	42·12	71.94	31·14	50·06
Great Salt Lake,	4351	40·46	75.92	32·08	53·24
Fort Kearny,	2360	40·38	71·47	23·04	47·67
Fort Defiance,	7200 ?	35·44	67·61	28·74	46·92
Santa Fe,	6846	35·41	70·46	31·64	50·59
Fort Graham,	900 ?	31·56	82·48	48·75	65·76
Fort Chadbourne,	2120	31·58	76·77	45·87	62·38
Fort M. Scott,	1300	30·10	76·94	47·24	62·46
Fort Brown,	50	25·54	83·58	62·09	73·75
Pacific Coast, Longitude 120° *to* 125° *W.*					
Fort Vancouver,	50	45·40	65·65	39·54	52·65
Fort Reading,	674	40·30	80·0	46.13	62 09
San Francisco,	150	37·48	57·33	50.86	54·88
Monterey,	140	36·36	58·64	51·22	55·29

Descriptions of new Coleoptera from the Western Andes and the neighbourhood of Quito. By ANDREW MURRAY. (Plate III.)

PART I.

Most of our readers must be familiar with the name and reputation of Professor Jameson of Quito, from the notices which have appeared, in this and other journals, of the collections he has sent home, and of the new or rare species of plants and animals which he has discovered. The Professor seems to be one of those rarely-gifted individuals whose genius embraces every branch of science. It enables him, while ably discharging his duties as professor of chemistry in Quito, and officially superintending the Mint of the State, also to explore the unknown regions of the country he lives in, and to contribute stores of information, and valuable collections in every department of Natural History, to the scientific world in Europe. In illustration of this, it will be enough to refer to the extensive botanical collections transmitted by him to Professor Balfour and the University of Edinburgh, and to the orchids supplied to Professor Lindley of London; to the numerous new and beautiful plants which have been raised by the well-known successful cultivator and hybridizer, Mr Isaac Anderson of Edinburgh, from seeds sent to him by Professor Jameson; to the mud-gatherings for diatomaceæ which have been communicated to Dr Greville; and to the new or interesting birds sent to Sir William Jardine and Mr Gould. I also have been fortunate enough to participate in the treasures which Professor Jameson periodically lavishes upon his friends and correspondents in this country, and have at various times received collections of insects made by him during his excursions among the upper Andes. The principal portion of the insects which have come into my hands have been Coleoptera; and among them, besides many already known, which are noteworthy, from their geographical distribution and affinities, there are also several new and interesting species, which I purpose to describe in the following pages.

The most striking of these are not from the country immediately around Quito, (which Professor Jameson informs me is not rich in insects), but from the warm and wooded valleys of the Andes, where nature smiles and puts on her gayest attire.

As might be expected from its position (occupying as it does nearly a middle place between the countries on the east and west of the Andes), the district in question furnishes not only species peculiar to itself, but also others properly belonging to the countries lying on each side of it. A considerable proportion of those which I have received are species already familiar to entomologists, as inhabiting the large tract of country formerly known under the name of Columbia, now broken up into several smaller states. Among the most striking of these I may mention ;—*Pseudoxycheila bipustulata, Sterculia fulgens, Philonthus flavipennis*, and *dives*, the rare *Latona spinolæ*, and *Conotelus vicinus, Oxysternon conspicillatum, Hoplites Pan*, the magnificent *Chrysophora chrysochlora, Lasiocala fulvohirta*, &c., &c. Of the species already known as inhabiting the Peruvian side of the mountains, the numbers have been fewer, the most striking being the curious *Golofa Eacus, Cybister laevigatus, Scarites auriculatus*, &c. Besides these, there are a considerable number of species, differing from any known to inhabit the adjacent countries. Some of these, such as *Ancognatha Scarabæoides*, Erichs., *Heterogomphus Bourcieri*, Guer., &c., have been already described, but the most of them still remain unknown. I shall endeavour to reduce the number of these, by publishing from time to time descriptions of some of the species which I have already received, or may in future receive from Professor Jameson. This mode of recording them will necessarily render it impossible to follow out any determinate arrangement. I shall, therefore, not attempt any, but shall merely take them as they come to my hands.

SPHENOGNATHUS, Buq.

This genus, which was originally erected by Buquet (after Dejean), *Rev. Zool.* 1838, possesses much interest, as being one of the links which connect the New Holland *Lamprimæ* with the South American *Chiasognathi* and *Pholidoti*.

The only species which have yet been described are *Sphenognathus Prionoides*, Buq.; *Sph. albofuscus*, Blanch; and *Sph.*

Feisthamelii, Guer. The former, which was first described, comes from Columbia, and approaches most nearly to the new species which I am going to describe.

This is already known in collections under the MS. name of *Sph. Lindenii;* that name having been bestowed upon it by the Parisian entomologists, to some of whom I supplied it when I first received it from Professor Jameson. This name I have retained.

1. *Sph. Lindenii*, Murr. (Pl. III.; male, fig. 1; female, fig. 2.)

Mas.—Statura *Sph. Prionoides* sed postice parum latior et mandibulis longioribus. Castaneus, supra æneo-virescens, mandibulis elongatis, porrectis, deflexis et apice recurvatis, plusquam duplo longioribus capite; oculis cantho divisis; thorace et capite longa pubescentia fulva vestitis, tibiis mediis et posterioribus fere simplicibus. Long. 15 lin., lat. 7 lin.

Male of the form of *Sph. Prionoides*, but broader behind, and with the mandibles longer. Reddish chesnut brown; thorax and head darker than elytra; in certain lights the upper surface (except the mandibles) has a faint greenish brassy reflection, which is most marked on the elytra; head and thorax, and under side, clothed with a long fulvous pubescence, which disappears on the disk of the thorax. Mandibles porrected, rather more than twice the length of the head, bent downwards about one-third of their length from the base, and slightly reflexed and incurved at the apex (which terminates in a curved tooth), with a ridge running along their upper side, interrupted or bent about one-third from the base; coarsely punctate or granulated on the upper side; smooth and more finely punctate, and with much more pubescence on the under side, particularly towards the base. A row of small teeth on the inner side of each mandible. Palpi dark brown; maxillarypalpi longish. Antennæ 10-jointed —first joint long; second, third, and fourth, short and round (third longest of the three); six last lamellar, gradually increasing to the ninth, which has the longest lamella. They do not differ from the antennæ of *Sph. Prionoides*, unless in that they are comparatively thicker, and the lamella of the ninth joint is perhaps more certainly longer than the tenth, while in *Prio-*

PLATE III.

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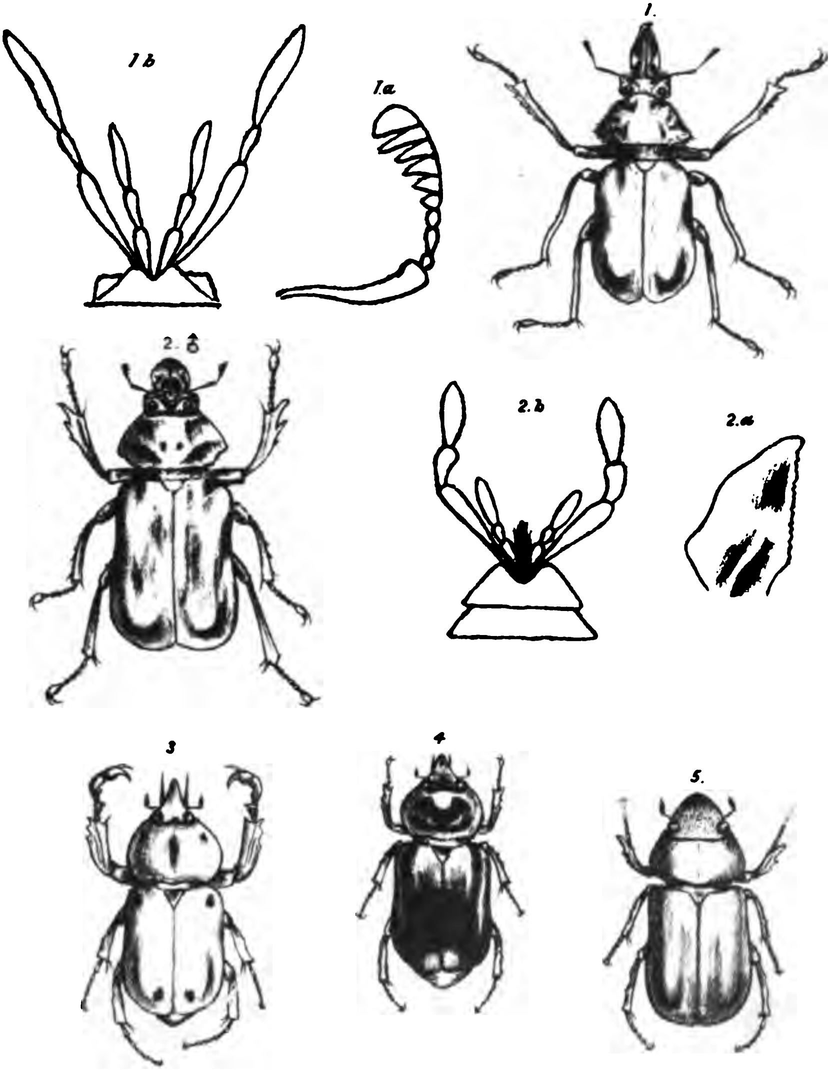

1. Sphænognathus Lindenii. ♂ 3. Ancognatha Crassimanus,
2. Do. Do. ♀ 4. Do. Jamesoni.

5. Leucothyreus gigas.

A. Murray Del et Lith.
W. H. Lizars Imp.

noides they are so nearly alike as to make it difficult to say that the ninth is longest. Eyes divided by a canthus, into a superior and inferior eye; a ridge surrounding the upper half of the eye like a circular eyebrow. *Thorax* coarsely punctate, except on disk, where it is more sparingly punctate, and has one or two prominences, shining and almost free from punctures. A large longitudinal depression occurs on each side in front behind the eyes, and an oblong transverse space is partitioned off, as it were, at each of the posterior angles, by two depressions which join each other nearly at right angles. There is a faint indication of a longitudinal dorsal line. In front the thorax is of the breadth of the head, and gradually becomes wider till about one-third of its length from the base, when it turns and slopes off more abruptly in a sinuated line towards the base, which is slightly emarginate. The pubescence, combined with the slight cutting in on each side of the body, gives the appearance of a tooth projecting there a little backwards. The space between the thorax and elytra, which in all the species of this genus is rather broad, is covered with a pubescence similar to that on the thorax, as is the scutellum, which is large, and nearly semicircular. *Elytra* polished and shining, and free from pubescence, covered with very minute punctures, not perceptible to the naked eye, which in many places run into each other, and give a sort of granular or chagreened appearance under the lens. Besides these, there are larger punctures or depressions irregularly scattered over the elytra, in places showing a slight tendency to run in rows. There are also a few shallow longitudinal depressions, which may be viewed as evanescent striæ. They are slightly depressed around the scutellum. The shoulders, and an elevation or haunch near the outer margin, towards the apex, are prominent. The elytra are expanded a little for the posterior half, and each is rounded in a little towards the suture; a distinct marginal line or thread, reflexed towards the base, goes round the elytra. *Legs* light, reddish chestnut-brown; tarsi long, and dark brown; anterior tibiæ long, flattened, incurved, obtusely denticulated on the outer margin; middle tibiæ with two or three very small teeth; posterior tibiæ with scarcely perceptible indications of denticulation.

The differences between the male of this species and that of *S. Prionoides*, are the following, viz.:—The mandibles in the former are nearly twice as long as in the latter, and are closer set together; the bend or interruption in the ridge on their upper side takes place at one-third from their base, while in *Prionoides* it is at one-third from their apex; and in the latter the ridge runs nearly straight to the head for the posterior half, while in the former it is curved for the short distance it has to go after the bend. The maxillary palpi here are comparatively longer. The thorax is somewhat differently shaped; it tapers towards the front more rapidly in this species. The punctuation is closer and deeper in *Prionoides;* the pubescence in it is cinereous; in this it is russet, or fulvous yellow; it is also in greater abundance here. The æneous lustre on this species is very distinct, while in *Prionoides* it is either wanting or scarcely perceptible. The elytra in this expand distinctly behind; in *Prionoides* the sides are more parallel to each other; in the latter the anterior tibiæ are narrower, and the teeth on the outer margin sharper and more developed; on the middle and posterior tibiæ the small teeth are distinct; whilst in this species they are either awanting or scarcely perceptible.

Femina.—Castanea, thorace transverso parce pubescente, angulis posticis virescentibus, corpore subtus cinereo-fulva pubescentia vestito. Mandibulis curtis, obtuse rotundatis, longitudine capitis; tibiis posterioribus, fere simplicibus. Long. 18 lin., lat. 8 lin.

Female.—Larger and broader than *Sph. Prionoides*, and with differently formed mandibles; dark chestnut; the posterior angles of the thorax virescent, the rest of the body without any brassy or green lustre; under side covered with a dull fulvous pubescence, which occurs also sparingly on the thorax. *Head* coarsely granular, with a transverse ridge having a granular elevation on each side in front, a somewhat triangular granular elevation extending backwards behind this. Mandibles short, like those of the female of *Chiasognathus Grantii*, and obtusely rounded, not longer than the head; inner side straight, denticulated, fitting to opposite mandible; outer margin raised, so that when the mandibles are closed they have the form of a shallow cup; their upper side is coarsely granular, lower side rounded, punctate, and pubescent; an oblique sharp ridge extends along the posterior half of the upper side. Eyes as in the male. The antennæ and palpi are comparatively shorter and thicker than in the male. *Thorax* transverse, and of a similar form, but not sloping so rapidly back to the projecting posterior angle, making the whole thorax broader and larger. A large depression on each side in front, between the eyes, and large depressions in each of the posterior angles, leaving a smooth elevated figure, of the shape of a widely expanded V, on the disk, which shows indications of a dorsal longitudinal line; deeply and densely punctured on the sides; more sparsely, but still deeply on the disc, which is polished. *Elytra* long and broad, somewhat expanded behind, wholly covered with minute punctures, scarcely visible to the naked eye, but coarser than in the male; also covered with larger corrugations, mostly running transversely, and some of which exhibit a tendency to longitudinal striation. The *tibiæ* are a good deal shorter than in the other species. The anterior tibiæ are broader, and the two last teeth are larger and more prominent. The middle tibiæ are denticulated, one tooth at least being sharp and prominent. The posterior tibiæ are almost simple, the denticulations doing little more than roughening their edge.

The above two insects are the only species of this genus which I have received, and as the one form is that of a male and the other that of a female, I assume them to be male and female of the same species. Perhaps this is jumping a little too rapidly to a conclusion; but they do not differ more from each other than the sexes of the other species do; and the fact that I have received considerable numbers of each, and never any other male or any other female form, induces me to think that I am right in classing them together.

PHANÆUS, M'Leay.

Ph. velutinus, Murr.

Mas.—Niger, opacus, sericeo-opalino-velutinus, thoracis lateribus, pygidio et femoribus subtus, rubro-cupreis, elytris leviter striatis; subtus minus opacus. Long. 8 lin., lat. 5¼ lin.

Male.—Deep black, opaque, with silky velvety opaline reflexions. *Head* with a nearly straight horn, very slightly bent back, scarcely longer than height of thorax; front and sides of head transversely strigosely granulated. *Thorax* excavated in front, and with two tubercules in the middle, projecting over the hollow, much broader and deeper in front than behind, the anterior angles projecting a little, and slightly reflexed; a narrow irregular space along the margins, of a rich dull red metallic copper colour, which also extends over the reflexed margin at the side of the posterior angles of thorax. There are two shallow depressions at the base of the thorax in front of the scutellar space. No scutellum. *Elytra* contracted at the base, margined with a raised line and reflexed margin, faintly striated; the striæ dull and impunctate, and each ending in a fovea at the base. *Pygidium* very faintly and sparingly punctate, opaque, of the same rich dull red metallic copper colour as the margin of the thorax; as also are the under sides of the thighs. *Under side* less opaque than upper; mesosternum not produced, nearly diamond shaped; anterior point of it a little pinched in, and with a slight depression behind it; anterior tibiæ, with two teeth and a sinuation, besides the terminal tooth.

One of the smallest species of *Phanæus*. A single male specimen is all that I have seen.

CHLOROTA, Burm.

1. *Ch. lineata*, Murr.

Statura *Euchloræ viridis*, sed magis elongatus et postice latior, nitens, viridis, levissime punctatus; elytris viridibus cum tinctura testacea translucenti disposita in vittis; mesosterno fortiter projiciente; uno ex unguiculis anterioribus bifido, unguiculis ceteris simplicibus; subtus roseo-cupreo-viridi. Long. 12 lin., lat. 6 lin.

Nearly of the same form as *Euchlora viridis*, but a little more elongate, and the elytra a little expanded behind; bright green, polished, shining, exceedingly faintly, irregularly punctate. *Head* with a few scattered, nearly imperceptible, punctures on the forehead, deeply and closely punctate along the clypeus; a black line like a crack starts from the corner in front of the canthus of the eye, and after a short distance breaks into two branches, which soon disappear; as in the rest of the genus, a short canthus half separates the eye into two. Labium emarginate. *Thorax* bright green, with a faint testaceous tint shining through here and there; very smooth on the disk, but a few small scattered punctures may be seen by the aid of a lens, and these are more numerous and visible (although still very faint and sparse) along the sides. The punctures are nearly uniform in size, not large and small mixed together; a marginal stria runs along the sides, not reaching wholly to the basal margin, is continued round in front of the anterior angles, but disappears immediately after; no marginal stria along any part of the base. *Scutellum* elongate, very smooth, nearly impunctate; the apex and margins next to it black. *Elytra* green, with a testaceous tinge shining through, which is disposed in longitudinal stripes,—in my specimen there are three such stripes visible on each elytron,—polished and shining, with scattered minute longitudinal punctures, disposed somewhat in rows, not visible to the naked eye. There are several impressions, like effaced striæ, and a few larger punctures, disposed irregularly along the margin near the base, like a marginal stria. *Pygidium* bright green, with a bronzy hue in some lights; irregularly transversely strigose. *Under side* and *legs* rich rosy copper, with the middle of the breast and basal portion of abdominal segments bronzy green; prosternum, sides of breast, and edges of thighs, thickly clothed with a fulvous pubescence; abdominal segments, except the last, strigosely punctate, with occasional hairs springing from the punctures, which are arranged chiefly in an irregular line, parallel with margins of the segments; last segment smooth and impunctate, except on the margins. Mesosternum produced into a strong decumbent spike, recurved at the apex; sides of breast obliquely strigose; middle, impunctate behind, but punctate in front; the punctures (from most of which a hair proceeds) extending up the mesosternal projection to nearly the point where the punctuation is abruptly terminated by a fine rounded line; a black suture runs down the middle of the mesosternum, with a branch projecting from each side, near the middle, like an arrow-head. One of the anterior claws of the only specimen I have received is bifid, while the middle and posterior tarsi have both claws simple, thus showing that my specimen is a male.

It is possible that the testaceous tinge seen shining through the green in this species, and forming the stripes on the elytra, from which I have given it its name, may appear more or less distinct, according to the maturity of the insect. Having received only one specimen, I cannot say as to this; but my specimen seems in all respects fully matured.

2. *Ch. Euchloroides*, Murr.

Statura fere *Euchloræ grandis*, et colore, et facie supra, et simillima. Politus, nitidus, viridis, punctatus, punctis majoribus et minoribus intermixtis, scutello grandi, mesosterno fortiter projiciente. Long. 13 lin., lat. 8 lin.

Nearly of the form of, and exceedingly resembling, *Euchlora grandis*, in colour and facies. Green, shining, and polished. *Head* finely and densely punctate, particularly in front. *Thorax* densely and finely punctate; the interstices between the punctures filled with a still finer punctuation, and both crowded together into a kind of granulation on the sides of the thorax. There is a marginal line and raised margin along the sides, which disappears after turning the anterior angles, and scarcely turns the posterior. The raised margin is more or less testaceous, sometimes quite yellow, and sometimes green, with a yellow tinge shining through. *Scutellum* large, longer than broad; the apex and adjacent margins black; very faintly punctate. *Elytra* green, with reflexed margin, which is more or less yellow, or green, tinged with yellow shining through; punctate, the punctures as if made from behind, some disposed in striæ, of which depressed traces are seen. *Under side* and *legs* green, with a faint coppery tinge in certain lights, particularly along the margins of the segments of the abdomen; pubescence on posterior sides of breast and edges of thighs not so dense as in preceding species; mesosternal projection and middle of breast with nearly the same markings as last species, but stouter and not punctate. I have only received female specimens with the tarsi perfect. They have the exterior claw in each tarsus bifurcate, as is the character of the claws of the female in this genus.

LEUCOTHYREUS.

1. *L. Gigas*, Murr. (Pl. III., fig. 5.)

Supra castaneo-cuprescens, glaber; antennis articulis decem, castaneis, clava rufa; capite magno, grosse denseque punctato-rugoso; prothorace fortiter punctato, lateribusgrosse punctatis-rugosis, marginibus denticulatis; scutello punctato; elytris inequalibus, lineis læviter elevatis signatis, humeris et spatio prope apicem prominentibus, læviter punctatis, punctis minoribus et majoribus interspersis; subtus cuprescens, sparsim fulvo-pubescens; pygidio punctato. Long. 14 lin., lat. 5½-6 lin.

Oblong, and rather depressed; dark, dull, coppery, reddish chocolate-brown, with dull reddish metallic lustre in parts, especially on the head and thorax, and thighs and abdomen; glabrous above. *Head* very large and broad, rounded in front, very deeply, thickly, and coarsely punctate; the clypeus chocolate brown, separated from the forehead by a faint suture; the forehead dull, coppery, reddish brown. Antennæ 10-jointed, chestnut-brown; club, pale and reddish. Eyes large, but not prominent; a short canthus encroaches on the anterior half. Labrum large, declive, projecting in front, foveolate; slightly metallic, and with some scattered fulvous hairs. *Thorax* short and broad, bisinuated behind, deeply emarginate in front; anterior angles prominent and acute, widest a little behind the middle; whole surface covered with large punctures, less deeply impressed on the disk, but very deep, coarse, and rugose on the sides, extending to and upon the raised lateral margin, which appears irregularly denticulate, as if from the large punctures having pierced through the edge and left circular breaks in its continuity. This raised margin is distinct and well marked on the sides, and extends along the base, but is awanting in front. The basal raised margin is virescent; there is the trace of a dorsal smooth ridge most distinct in front. The *scutellum* is dull metallic red, with virescent margins; it is triangular, with the apex rounded, and is distinctly punctate, though not so coarsely or deeply as the head and thorax; a faint irregular impunctate raised line passes down the middle. The *elytra* are smoother, particularly on the disk; but are so closely covered with minute punctures as to have something of an opaque appearance. Besides these minute punctures, there are others of various larger sizes scattered among them; and a third class of still larger punctures is also to be seen, which have a tendency to run in striæ. The whole of these punctures, however, are very shallow, and have no resemblance to the deep punctures on the head and thorax. They are most deeply impressed about the base of the elytra. The disk is flattish, the shoulders are prominent, and a sort of ridge connects them with an apical prominence, the sides falling rapidly down on each side, and expanding somewhat behind; the wings are long and brownish. *Pygidium* finely punctate—most closely and finely at base. The *under side* is of the same colour as the upper; the abdomen and thighs are smoother and more shining. Prosternum, and especially mesosternum, clothed with longish fulvous pubescence; mesosternum coarsely punctate; segments of abdomen more faintly and sparingly punctate; punctures deepest along the margin of the segment; legs coppery, dark reddish brown, with faint metallic lustre; anterior tibiæ with three teeth; tarsi moderate in length, and slightly thickened. In the only specimen I have received, the middle tarsi have the outer claw bifid, and the posterior tarsi the claws simple;—the anterior claws have been broken off.

ANCOGNATHA, Erich.*

1. *A. Jamesoni*, Murr. (Pl. III., fig. 4.)

Testacea, nitida; vertice, pronoti disco, elytrorum disco et margine plus minusve nigris vel piceo-nigris; pronoto elytris augustiore; scutello lævissime punctato; elytris geminato-punctato-striatis, postice parum dilatatis; geniculis, tibiis extus et tarsis plus minusve piceis. Long. 12 lin., lat. 6 lin.

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* Notwithstanding the high authority of Professor Lacordaire (Hist. des Ins. iii., 399), who disallows this genus, and retains it as a portion of the Genus *Cyclocephala*, I agree with Erichson in holding that the characters he has given, more especially the recurved mandibles, are sufficient to justify its being retained as a distinct genus, although they may not be of equal value with those of the great genus from which he has separated it.

Testaceous, more or less clouded, or marked with black, or piceous black. *Head* conically produced, and recurved like a sow's snout; rugosely punctate, the edges and front with a reflexed black margin; two tubercules, united by a curved ridge between the eyes, making a slight separation between the front and back of the head; these tubercules and ridges, the vertex and the reflexed margins of the head, are all more or less distinctly marked with black or dark brown. Mandibles black, protruding, tapering, recurved; but not reaching so far as the end of the snout. Palpi and antennæ blackish brown; antennæ with ten joints. *Thorax*, with two or three depressions or irregularities in the surface on each side of the disk; more or less clouded with black or dark brown, often enclosing two testaceous spaces on the disk; smooth and shining, sparingly punctate, at its widest narrower than the elytra; when seen in profile, not rising in a curve from the base, but proceeding straight forward, and rounding down towards the apex; margin with a raised edging along the sides in front and a short part of the base next the angles, but not on the middle of the base, which is slightly bisinuate; sides rounded, slightly oblique behind, widest a little before the middle, rapidly contracted in front; anterior angles slightly projecting; posterior angles rounded. *Scutellum* triangular; lateral sides very slightly sinuate; sparingly and faintly punctate; testaceous, with a larger or smaller black or dark patch, which is more or less interrupted with testaceous. *Elytra* shining, of rather a coarse texture, more or less clouded with black, the extent of the black varying much. The testaceous portions are usually a space around the scutellum, extending a short distance along the suture and along the base, sending down for a short distance about the middle an arm parallel to the suture, then to the shoulder, after rounding which, at the very base, it turns down and sends an elongated stripe parallel, or nearly so, to the exterior margins, sometimes continuing more or less distinctly round the whole elytron, till it reaches the suture near the apex, where there is almost always a testaceous patch on each side of the suture. The sides of the elytra are not quite parallel, being a little expanded behind the middle. Each elytron is deeply punctate striate, as follows, viz.,—a single regular row of punctures runs next the suture, then follows a space with two or three irregular rows, then two regular rows, then two or three irregular rows, then two regular rows, two or three irregular rows, two regular rows, and the remainder irregular rows. Margin with a reflexed border, which is expanded about the middle of the elytron. *Pygidium* testaceous, rather large, smooth and impunctate; upper side of penultimate segment of abdomen finely punctate. *Under side* of body wholly testaceous; mesosternum clothed with long fulvous hairs; prosternum less hairy, and abdomen with only a few hairs along the margins of the segments, where, as well as on the sides, there are a few punctures. *Legs* testaceous, with a tinge of piceous or brown at the knees, and along the outer margin of the tibiæ; the anterior tibiæ have three teeth. The tarsi wholly piceous, long and slender. The claws simple, and of equal proportions.

This species bears considerable resemblance to *A. ustulata* (Dej.), Burm. Its system of coloration is the same, and its general form is also very near it; but it is larger, of a coarser texture, and has the head and thorax punctate, and the elytra punctate and geminato-punctate striate; whereas in *ustulata*, the head and thorax are smooth and impunctate, and elytra only very faintly punctate.

I have received many specimens of this species from Professor Jameson, in honour of whom I have named it, but I do not find in any of them the thickening of the anterior tarsi, usually seen in the males in this genus. It may be that they are all females, but I have not been able to ascertain this by dissection, in consequence of the interior of the insects having been eaten away by larvæ on their way home.

2. *A. crassimanus*, Murr. (Pl. III., fig, 3.)

Præcedenti valde affinis, sed major et robustior, capite et mandibulis grandioribus; thorace latiore, latitudine elytris equali; scutello fortiter strigoso-punctato; elytris fere parallelis, vix postice dilatatis; pedibus anterioribus valde incrassatis.

Colore testaceo, thorace macula oblonga dorsali, et duabus parvis maculis rotundatis in angulis anterioribus piceis signato; elytris maculis parvis humeralibus et apicalibus piceis signatis. Long. 13½ lin., lat. 6 lin.

Closely allied to the preceding species. Testaceous, with the back part of the head, a dorsal elongate patch and two faint spots in the anterior angles of the thorax, a patch at the base of the scutellum, the sutural line and the exterior margin, as well as a humeral and apical spot in each elytron, piceous or blackish brown. *Head* finely rugosely punctate, projecting very much, and turned up like a sow's snout; the margins with a reflexed black border; the mandibles projecting forward, and recurved like a boar's tusks, extending a third of their length beyond the muzzle; a curved transverse depression between the eyes. The back part of the head marked with a transverse line of black, widest in the middle. *Thorax*, very convex when seen in profile, rising with a curve both from the base and apex, widest a little before the middle, broader at its widest than the elytra; anterior angles acute and produced; posterior angles obtuse and rounded; base bisinuate. It has a reflexed piceous margin all round, most distinct on the sides, which are so much expanded and reflexed as to leave a small gutter between the edge and the body of the thorax; is covered with scattered shallow punctures, and somewhat granular towards the sides. *Scutellum* rounded; triangular, granular, or rugosely punctate at the apex; smooth behind. *Elytra* with the sides nearly parallel, and scarcely dilated behind the middle; with a reflexed margin, most prominent in the middle; punctate striate, the striæ running in pairs, and the interstices irregularly punctured, as in the last species. *Pygidium* with some longitudinal corrugations. *Under side* of body testaceous, with a testaceous pubescence, principally on the mesosternum. The anterior legs are very much thickened, and the tarsi, and more especially the last joint and claws, greatly developed. The anterior tibiæ have three teeth; the middle and posterior thighs and tibiæ are robust, but the tarsi are long and slender. The outer claw of the anterior tarsi is much larger than the inner. The middle and posterior claws are simple, and of equal proportions.

Although this species is very closely allied to the preceding,—so much so as to suggest the idea of its being its male,—I find so many points of difference which I cannot consider sexual, that I am satisfied it belongs to a distinct species. Putting aside the difference in colour, which may be ascribed to the score of variation, the much more developed mandibles, and the immensely thickened legs and anterior tarsi, and the smaller pygidium, which may be viewed as sexual (although in no other species of the group are sexual differences developed to such an extent), we have very marked differences in the proportions and form of the head, thorax, and elytra; the head is proportionally broader and more projecting in front, and the inequalities on the surface are fewer and less marked than in *Jamesoni;* the thorax and elytra are more shining and smooth in the latter, the punctures deeper and better defined. The thorax is of a different form; in *Jamesoni* it is not nearly so convex, the curve proceeding gently and gradually from the base without any rapid or abrupt rise; while in *Crassimanus* it takes a very marked rise, both in front and behind; in the latter also it is broader than the elytra; in the former considerably narrower. The former has the anterior angles only slightly produced; the latter has them much more projecting. The reflexed margins are greatly more marked in *Crassimanus,* which also has the margin all the way round; while in *Jamesoni* it disappears on the base. The scutellum is smooth and nearly impunctate in the one; in the other it is strigosely granular. The elytra in *Crassimanus* are proportionally longer and narrower, and are nearly parallel, very slightly, if at all, dilated behind; while in *Jamesoni* the dilatation is well marked. In it the pygidium is smooth and shining; while in this species it is dull, and has a number of longitudinal grooves or striæ. These differences satisfy me that the two species are distinct.

I have only received a single specimen of this species, and its very curious greatly-developed anterior tarsi leads me to suppose that it is a male.

On the Influence of Magnetism over Chemical Action.

By H. F. Baxter, Esq.

The following inquiry originated in an endeavour to ascertain whether *Magnetism* possessed any influence over *Organic Forces*, and the kind of experiments that were undertaken for the purpose of solving this question, was that of submitting seeds *during* vegetation to the influence of magnetism.* These experiments, however, having failed to give us any definite or decided result, we were ultimately, and perhaps naturally, led to ask ourselves the question, *Does magnetism possess any influence over chemical action?* The solution of this question appeared to be almost a necessary preliminary step to the continuation of our original inquiry.

We shall not in the present inquiry enter into any lengthened detail of the numerous experiments we have undertaken, the results of which were negative, but proceed at once to the main object of our paper, which will be, on the present occasion, the influence of *Magnetism* (in its *static*† or quiescent condition) over *chemical action*; leaving the second part of our inquiry —the influence of *Magnetism* (in its *dynamic* condition, or when in motion) over *chemical action*—to a future occasion.

Part I.—*The Influence of Magnetism (in its static or quiescent condition) over Chemical Action.*

For the convenience of discussion, we shall arrange our present subject under three heads, reversing the order we pursued in our inquiry. *First,* On the *directive* influence of magnetism (static) over *chemical action; Secondly,* Does magnetism (static) *increase chemical action?* and, *Thirdly,* Does magnetism (static) *excite* or *originate chemical action?*

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* To the Council of the Royal Society, who liberally granted the use of their large magnet, and to Professor Wheatstone, for the loan of his large electromagnet, we are greatly indebted, and also to the Government Grant Committee of 1855, who granted the sum of £30 for the purpose of carrying on the present inquiry.

† We feel some difficulty in thus expressing ourselves. Can we, for instance, consider the *force* in a steel bar magnet, when quiescent, as being in a *static* condition? We cannot do better than refer to Professor Faraday's papers, and amongst others to that published in the *Phil. Mag.*, June 1852, *par.* 3251, 3269, for the purpose of expressing *our* meaning. We have no wish to depreciate the opinions of other philosophers, but stronger reasons than those that have been already urged against us for adopting the opinions of this eminent individual, must be assigned before we can consider his views as incorrect; whether we are right or not *time* alone must show.

§ I. *On the Directive Influence of Magnetism over Chemical Action.*

Professor Wartmann,* in the course of his investigations, found that when a bar of iron was magnetized, and placed in a solution of sulphate of copper, a *rotation* of the fluid occurred around the pole. Chemical action of a certain intensity, and that the bar should be in a state of magnetization, were, he considered, requisite and necessary conditions. He refers it to "a new instance of electro-magnetic rotation;" and also states that Professor Grove, by placing an iron bar, suspended to a powerful magnet, in dilute sulphuric acid, had observed the same phenomenon, and that Professor Christie had likewise obtained this rotation.

In the following experiments we made use of a straight bar electro-magnet, in the following manner:—The bar, of soft iron, was fifteen inches in length, and seven-eighths of an inch in diameter. To one end a glass vessel, five inches deep, two inches and three quarters in diameter, open at both ends, was fixed by means of a cork, through which the bar passed to the extent of two inches. This experimental cell, which we shall designate as the upper cell, so arranged, was capable of holding ten ounces of fluid. The other end of the bar could be easily passed through the helix, and placed in another glass cell, containing any solution or not, according to circumstances, and this we shall hereafter designate as the lower experimental cell.

The *helix* consisted of about three hundred yards of covered, rather thin, wire; it was four inches in length, one inch in internal diameter, and one inch and a half in external diameter.

The *battery* consisted of six of Grove's middling-sized cells.

Pouring some saturated solution of sulphate of copper into the upper cell, but not to cover the bar, and looking down upon the bar, no effect is at first observed: after a short time, as the copper is deposited upon the bar, a slight narrow *rotation* may be observed around the bar, near the surface or sides of the bar; this may, however, soon subside, and some considerable time elapse before the *rotation* recommences. It is best seen when fine particles are floating *in* the solution, and may be observed below the surface before the upper layer of the solution is affected. If pieces of cork, or any other light substance, be placed on the surface of the fluid, they usually floated either to the side of the bar or to that of the vessel. The *rotation* extended to some distance from the bar, and upon looking down upon the fluid, it had the appearance as if the whole mass moved. It generally occupied two minutes in making a complete circuit, it was, however, sometimes less, and at other times longer. Shaking the vessel did not put a stop to the rotation. Adding a few drops of nitric acid to the solution increased the effect, and by rendering the solution darker, made it more distinct; but it was found that if too much acid was employed, and if the hydrogen gas was evolved too rapidly from the surface of the bar, the rotation soon ceased. Stirring the fluid round in the contrary direction to that taken by the fluid during *rotation*, did not destroy the latter, it soon regained its former direction.

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* *Phil. Mag.* 1847, p. 363.

The *direction* of the rotation was dependent upon the pole of the magnet. When the wire connected with the zinc end of the battery was uppermost, and consequently the upper end of the bar corresponded to the marked pole of a magnetic needle, the *rotation* went from right to left, round by the east, through south, to the west. Upon *reversing* the poles, the *rotation* was *reversed;* and upon breaking the circuit entirely, it ceased altogether. The *rotation* appears, therefore, to be in the contrary direction to that which is supposed, according to Ampère's theory, to circulate around a bar-magnet.*

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* Wartmann states, that "it is directed like the current of Ampère:" but he calls that the north pole, "at which the current enters." Some, we believe, consider the pole of the magnet, which points to the north, to be in reality the south pole of the magnet. We think we are right, however, in considering that the *current* which is supposed to circulate around a magnet, in accordance with Ampère's theory, is similar in direction to that which circulates around the helix forming the magnet.

When the cell was completely filled with the cupreous solution, so as to cover over the pole, the *rotation* did not appear to extend but just above the pole.

The *lower* end of the bar was placed in a glass jar, two inches and a quarter in diameter, and four inches deep, containing some of the cupreous solution, extending about an inch up the bar. The *rotation* was observed as in the upper cell, but in the *reverse* direction, and in the *same* direction as if the lower pole had been *inverted*, looking upwards. Under the supposition that currents circulate around the magnet in a certain determinate direction, according to the theory of Ampère, we expected to find that the *rotation* would have occurred in the same direction as in the upper cell, whilst the bar continued in the same position, being straight, and not of the horse-shoe shape; but the *rotation* was in accordance with the nature of the pole, whether inverted or not.* It occasionally happened, however, and this at first misled us, that an apparent rotation occurred in the opposite direction, which evidently arose from the following circumstance: upon pouring some of the solution into the vessel, from the narrow space that existed between the bar and the sides of the vessel, a circular motion of the fluid was produced; and if a slight evolution of hydrogen gas occurred upon the surface of the bar, this assisted in keeping up this circular motion. Filling the glass carefully with the solution, this motion was prevented from occurring, and the *rotation* was ultimately observed to take place as we have stated; it did not occur, however, high up the bar, but was very distinct near the end of the bar. Occasionally two distinct circles were observed to occur, rotating in the fluid, separated by a narrow band of liquid. Whether this narrow band was quiescent, or whether it was rotating, but not apparent from the particles not being perceptible, we are at present unable to decide.

The appearance of the *rotation* in the two cells was, generally speaking, not simultaneous, although the same solution was employed, the poles equidistant from the helix, and the two vessels of the same size and diameter. It usually commenced in one cell earlier than in the other.

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* Since this paper was written we have found that De la Rive has made similar observations upon the electro-magnetic rotations of mercury.—(*Mémoires de la Société de Physique de Genève*, t. iii. p. 127.)

Instead of the *cupreous* solution we now employed *dilute sulphuric acid* in the same manner. In these experiments we obtained the *rotation* as before, and in the same *direction*, being *reversed* when the poles were reversed, and *ceasing* entirely upon the *breaking* of the circuit. It was necessary, however, in these experiments to take care that the *acid* solution should be very weak, for it was found that a too rapid evolution of hydrogen gas created currents in the fluid, which interfered with the results. The *rotation* did not commence immediately; and under the supposition that the density of the fluid might have some influence, we dissolved some sulphate of iron in the solution with apparent advantage.

It was interesting, in these experiments, to observe the iron, as it separated from the bar, thrown off in jerks, like radii, at right angles to the bar, to some distance in the fluid, where it gradually dissolved; or forming a thin convex layer, like the upper surface of an open umbrella. At these times, however, the *rotation* was not observed, and it was only during the time when the evolution of gas took place very quietly that it occurred.

When a solution of *sulphate of zinc* was employed in the same manner, we did not obtain any effect, but upon adding some nitric acid to the solution, the *rotation* ultimately occurred as in previous experiments.

As far as we have thus gone, our experimental results confirm those obtained by Wartmann, and perhaps those of Grove and Christie;* and we shall now make one or two observations in a general manner, in reference to the circumstances which appear to us to be influential in producing or interfering with the results. These may for the present be considered under three heads:—*First*, The *strength* of the magnet; *Secondly*, The *density* of the fluid; and, *Thirdly*, The *chemical action*. If the chemical action be of that nature that a gas is evolved from the surface of the magnet, and powerful in its action, so as to occasion a rapid evolution of gas, vertical currents are created in the fluid, which interfere with the *horizontal* motion; and no *rotation* is observed. On the other hand, as already remarked by Professor Wartmann, unless the chemical action occur, and is of sufficient intensity, and what is, we may add, of the utmost importance, unless it should *continue*, the *rotation* is not obtained. With the cupreous solution we frequently observed the *rotation* to occur, then stop for some time, and ultimately recommence and continue. If the bar be perfectly smooth and polished, the copper is deposited in a firm compact layer, difficult to remove, even by scraping; this appears to put a stop to the chemical action, and the rotation is checked; should the bar, however, not be polished, the copper is deposited in patches, easily removed, presenting a striated appearance, and does not form a firm, compact covering to the bar. This copper falls off in flakes, and, as the chemical action is thus allowed to go on upon the surface of the bar, the *rotation* continues. That the *density* of the fluid is not without some influence, may be seen in those instances in which sulphate of iron was added to the *acid* solution with manifest advantage. In these instances it could only have acted by increasing the *density* of the fluid, and not by its chemical agency. We shall relate some other experiments presently, in which the same facts were observed.

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* The only knowledge we have of the experiments of the two latter philosophers is from the facts, as related by Wartmann (*loc. cit.*). We ought, perhaps to allude to the experiments of Mr Hunt, recorded in the "Philosophical Magazine," June 1846, and in the "Memoirs of the Geological Survey of Great Britain," vol. i. 1846, in which he caused different solutions to react upon each other over the poles of an electro-magnet of the horse-shoe form. When he employed a solution of caustic potash and muriate of tin, "curves of repulsion" were formed, which were reversed upon the reversal of the current. We have employed similar solutions in a similar manner over the pole of a straight bar electro-magnet, as well as over the poles of the electro-magnet of the horse-shoe form; but we have not been able to obtain any *rotatory* motion, the effects were those of *repulsion*, and appeared to be similar to those observed

If the magnet be *powerful*, as appears to have been the case in Professor Grove's experiments, light bodies, such as pieces of cork, may be made to rotate around the pole. It is reasonable also to suppose, that, in those cases in which the

by Plücker in his experiments (Taylor's Scientific Memoirs, vol. v. p. 567), and by Matteucci (Comptes Rendus de l'Académie des Sciences, 23 Mai 1853), and may be considered as *diamagnetic* in their character.

chemical action is either too weak or too powerful (from the evolution of gas) for the *rotation* to occur with weak magnets, it would become manifest with *powerful* magnets.

The question now arose, Is it necessary for the *rotation* to occur, that the *chemical action* should take place *upon* the magnet?

Rings of the following metals—zinc, copper, and tin—were procured, each two inches in height, and one inch in diameter. These rings were placed over the ends of the iron bar, with a layer of caoutchouc in the form of a cap, intervening between the bar and the ring, for the purpose of preventing any chemical action from taking place upon the iron bar. With the *zinc* rings surrounding the ends of the bar, and very dilute sulphuric acid in the experimental cells, the *rotation* was obtained, as if the iron bar alone had been employed, and in the same *direction*, being *reversed* when the poles were *reversed*, and subsiding upon the *breaking* of the circuit. To increase the *density* of the fluid, some sulphate of zinc was added which rendered the *rotatory* motion more evident.

With the *copper* rings and dilute sulphuric acid employed in the same manner, no effect was at first obtained, but upon adding some nitric acid to the solution, it ultimately occurred. In this instance the effects were the same as with the *zinc* rings. Some sulphate of copper was dissolved in the solution with manifest advantage.

With the *tin* rings and dilute muriatic acid no effect; adding some nitric acid, the *rotation* was ultimately obtained, but not so distinct as in the former experiments; the *rotation*, however, was in the same *direction*, and reversed upon the *reversal* of the poles.

The proper strength of the acid in these experiments was best ascertained in the following manner:—The solution being poured into the cells, if no signs of the evolution of gas appeared around the surface of the metal, strong acid was carefully and gradually added and stirred in the fluid, until a small ring of gas bubbles appeared upon the surface of the solution around the metallic ring. Should the evolution of the gas be too violent, the solution was then weakened either by dilution, or, what was better, by adding a salt of the same metal.

We may add, that the *direction* of the *rotation* in the lower cell in all these experiments was the reverse of that observed in the upper cell. The appearance of the rotation in the two cells did not always coincide, evidently indicating that circumstances affecting the chemical action were in operation.

When the *rings* were employed without the magnetized bar no *rotation* was observed.

As it is not necessary for the production of this *rotatory motion* that the chemical action should occur *upon* the magnet, we were next led to the following series of experiments, for the purpose of ascertaining whether, during the reaction of different solutions upon each other, this *rotation* might not also be obtained, and the experiments were conducted as follows:—The lower end of the iron bar was placed in a small porous earthenware cylinder, an inch and a-half in diameter, and three inches in height, this was placed in the glass jar. We now had an opportunity of placing any solution in the porous jar, and another in the glass vessel external to it. Some liq. potassæ was placed in the porous jar, in contact with the iron bar, and dilute sulphuric acid in the external glass vessel. Under this form of the experiment we have never as yet been able to obtain any *rotatory motion* either of the internal or external fluid. In order that the chemical action should occur upon the *surface* of the septum, and not *within* the septum, the different solutions were kept at different heights in the two cells; and although the carbonic acid, in some of the experiments, was given off from the surface, we have never yet been able to obtain any effect indicative of magnetic influence, whether rotatory or otherwise. When acids were employed, and placed in the porous jar, a cap of caoutchouc was placed over the end of the bar to prevent any action upon its surface. The solutions we employed were those of the different salts of potash, soda, ammonia, iron, copper, zinc, alum, and lead, with the mineral and vegetable acids, such as the sulphuric, nitric, muriatic, tartaric, citric, and oxalic. The solutions were of different strengths,—sometimes concentrated, at other times very weak. The salts of the alkalies, or the metallic salts, were placed in substance, either in very fine powder, or moistened, into the porous cell, so as to form, as it were, a column of salt; still we could never obtain any effect.

On the supposition that the earthenware porous septum might have been too thick, other septa were formed, either of animal membrane, or of stout or fine calico, and employed in the same manner, but with the same negative result.

What can be the cause of our failures in these latter experiments? Is it in consequence of the magnet being too *weak* that its influence is not felt? Or is it in consequence of the chemical force being evolved and disposed of in such a manner as not to fulfil the conditions which are essential and necessary for the production and continuation of the rotatory motion, which we have observed in our previous experiments?

We have now arrived at that stage of our inquiry, at which we may be permitted to enter upon a few theoretical speculations, and endeavour to ascertain, if possible, the mode in which the results we have hitherto obtained appear to be brought about; but previous to doing this, it will be necessary to see what the conclusions are which our experiments tend to establish. They are :—

First, When the pole of a magnet is placed in a vessel containing a solution, which is capable of acting chemically upon the iron bar, a *rotation* of the fluid is produced; the *direction* of this *rotation* depending upon the pole of the bar. This conclusion has been already deduced from the experiments of Wartmann, Grove, and Christie.

Secondly, That it is not necessary for the production of this *rotation* that the solution should act (chemically) *upon* the iron bar, for if the bar be surrounded by a metal ring, the *rotation* is produced, and takes the same *direction,* provided the solution is capable of acting chemically upon this metal.

Thirdly, That the *influence of the magnet,* as well as the *existence* of the chemical action and its *continuation,* are essential and necessary for the production of this *rotation.* This conclusion has been already deduced by Wartmann from his experiments.

Professor Wartmann considers these phenomena as " a new instance of electro-magnetic rotation," analogous to those in which mercury is made to revolve round a magnetic pole when traversed by an electric current. He also states, that by placing the platinum electrodes of a rheometer alternately,—one near the margin of the vessel, the other near the bar,—that a *current* may be detected and shown to exist, traversing the solution in this direction, viz., from the margin of the vessel *to* the bar. He considers, also, that the electro-chemical action which occurs when an iron bar is placed in a solution of copper determines an electric current, which proceeds from the peripheric parts to those immediately around the cylinder, in the direction of the prolonged radii of the latter.

In classing these phenomena (as Professor Wartmann has done, and, as we think, rightly) with the ordinary *electro-magnetic rotations*, such as those in which wires, or even cylinders of metal, are made to rotate around the pole of a magnet, as may be seen in the experiments of Ampère, Savary, Barlow, Faraday, De la Rive, and others,*—there is one circumstance which cannot but strike the attention of the most superficial observer as existing in the latter class of facts, and which is absent in the former; we allude to the apparent necessity of a path or conductor for the circulation of the electric current in the latter phenomenon, without which it is supposed the effects would not occur; whilst this path for the circulation of the current is not so evident and apparent in the former phenomena, and appears to be wanting. Now, if the ordinary phenomena of electro-magnetic rotations, which we have referred to, are due to the action of angular currents upon each other, according to the law deduced by Ampère, or to the law of magneto-electric induction, as deduced by Faraday,† it becomes a point not only of some interest, but also of some importance, to ascertain and trace out, if possible, the path of the *current* in those cases in which the *rotation* of the fluid occurs without the intervention of any metallic conductor for the *current*. Wartmann says, that the galvanometer indicates a *current* to be traversing the liquid *from* the circumference *to* the centre of the solution. In order to account for the *rotation* of the fluid, according to the law of angular currents, this is the path the current would theoretically take. The metal (copper) being deposited *upon* the bar would also indicate that the bar was the *cathode* of the voltaic circuit. Upon placing the platinum electrodes of the galvanometer in the solution in the same manner as pointed out by Wartmann, we have frequently obtained similar results, viz., the electrode in the neighbourhood of the bar being *positive* to the other; occasionally the galvanometer indications were in the *reverse* direction; most frequently, however, no definite result was obtained with the instrument, but merely slight vibrations of the needle occurred. The galvanometer employed was not a very delicate one; nevertheless the indications were not constant. If one electrode was in the solution, and the other on the bar, the latter was, generally speaking, *negative* to the other, and during this period the *rotation* continued. In the other experiments, however, viz., when the sulphuric acid solution was used with the iron bar, or with the metal rings when surrounding the pole, the electrode in contact with the metal was always *negative* to the other in the solution, yet the *direction* of the rotation at this time was that in which the *current* would be supposed to be travelling *to* the metals. If the electrodes were both in the fluid, one near the metal and the other at the circumference of the solution, no definite indication of a current existed. When the metal and the solution were formed into a circuit by means of the platinum electrodes of the galvanometer, we had the well-known elementary circle formed, and the resulting current travelling *from* the metal acted upon through the liquid *to* the other. We placed the electrode in contact with the bar in different parts of its surface, at the extremities of the bar-magnet, and as near the middle as we possibly could through the helix, but on whatever part of the bar the electrode was placed, it was always *negative* to that in the solution.

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* In Becquerel's Traité de l'Electricité, vols. ii. and iii., will be found an account of these phenomena, to which we must refer, and also to De la Rive's Treatise on Electricity.

† "Experimental Researches," vol. i. p. 32, *par.* 114.

Although we feel some difficulty in tracing out satisfactorily the exact path of the *current*, or, perhaps, more correctly speaking, the "line of electro-dynamic force;" and although the galvanometer indications are such as to indicate that the metal or the pole is *negative* to the solution, we nevertheless believe that the chemical action which occurs and gives origin to the *current*, and consequently to the rotation, is such as to correspond with the supposition that the current travels *to* the bar or pole of the magnet, in accordance with Wartmann's view; but that the *current* travels from the *circumference* to the centre of the solution is not quite so evident. The *cation* being evolved upon the surface of the bar or metal either as a gas, or deposited as a metal, as is seen with the cupreous solution, would indicate it to be the *cathode*. The currents occurring upon the bar or metal are *molecular*, and, under ordinary circumstances, are free to take up any position; but under the influence of magnetism they are compelled to take up a certain definite direction, the magnet being the fixed point, the fluid alone moveable. This *direction* we are inclined to believe is *horizontal*, not *vertical;* circulating around the bar as several minute *circular* currents, and not travelling *from* the circumference of the solution *to* the centre. From what we have observed during the rise and progress of the *rotation*, it would appear to arise around the surface of the pole in the first instance, and gradually to extend in the fluid; the *action* which gives *origin* to the *rotation* may, and no doubt is, confined to the surface of the pole, but the influence may be felt at some distance, the outer portion of the fluid being inert as far as the *production* of the *rotation*. The *rotation* ceasing when the gas is evolved too rapidly from the surface of the bar, would tend to confirm this view; for in these instances, from the evolution of the gas, these *molecular* currents become vertical, as in ordinary cases; and it is only when the power of the magnet is sufficiently felt, as appears to have been the case in Professor Grove's experiments, that they are compelled to take up the *horizontal* direction; hence the *rotation*. In our endeavours to obtain the *rotation*, by placing the magnet in the *horizontal* position, we for a long time failed, but have at last succeeded in obtaining it with the *cupreous* solution. The greatest care is requisite in preventing the fluid from escaping from the vessel, otherwise the slightest flow of liquid will prevent the *rotation* from occurring. When hydrogen gas was evolved from the surface of the bar, it usually adhered to its under surface, and at present we have not been able to obtain the *rotation* when employing acid solutions. Terrestrial magnetism may have some influence in these experiments.

There are one or two circumstances we may just allude to: the particles that are seen floating in the fluid show no tendency during *rotation* to go either *from* or *to* the centre, they always appear to keep in the same relative position; and the *direction* of the *rotation* (when once it was firmly established), was almost *immediately* changed on *reversing* the poles. Time, it would appear, was not required to enable the fluid to undergo any peculiar change.

We have not as yet been able to obtain a *rotation* in the reverse *direction*, viz., under the supposition that the *current* travelled *from* the pole *to* the solution. When we employed the different solutions and the porous septum, we had this object in view, but have hitherto failed in obtaining it. In some experiments we have recently undertaken, and in which we employed a metallic ring of some size, so as to contain the solution, and covered the polar end of the bar with caoutchouc, so as to prevent any chemical action from occurring upon its surface, we have obtained some evidence of a *rotatory* motion of the fluid *within* the cell,—being the *reverse* of that which would happen when the chemical action occurred upon the *external* surface, the magnetic pole being within. And in reference to the non-appearance of the *rotation* when the solutions alone were employed, it becomes a question whether the chemical action of mere *combination* without *decomposition*, if such an effect can occur, is incapable of producing a *rotatory* motion; or whether it requires one of the elements to be in a solid condition, so as to act as a conductor to the "line of electro-dynamic force." This remains to be decided by future experiments.

Before we conclude this part of our inquiry, we must refer to some remarks made by Professor Grove in the last edition of his valuable work,* in which he states, "that when substances are *undergoing* chemical action, and a magnet is brought near them, the direction or lines of action of the chemical force will be changed." We are not aware that Professor Grove has published any experiments in support of this view beyond those we have already related.

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* On the Correlation of Physical Forces, 3d edit., 1855.

§ II. *Does Magnetism (in its static or quiescent condition) increase Chemical Action?*

That magnetism possesses some influence over chemical action has been long believed; and in Professor Wartmann's* valuable paper will be found a long list of authors who have treated of the subject, together with a reference to their respective publications.

Professor Wartmann placed a voltameter, in which some acidulated water was electrolyzed, between the poles of a powerful electro-magnet, but whatever the direction and intensity of the magnetism engendered, and whatever the position of the voltameter, within or without the polar arms, the volume of gas, he states, remained the same. He also adds that Professor Grove has been led to similar results.

By placing cylinders of soft iron in vessels containing sulphate of copper, converting them into temporary magnets, and then passing a *current* so as to decompose the solution, in whatever position in reference to the magnetic meridian these poles were placed, Professor Wartmann could detect no difference as to the quantity of copper deposited upon the cylinders.

Matteucci† has performed experiments in some respects similar to those of Professor Wartmann, viz., submitting an electrolyte, when traversed by a current, to the influence of a magnet; the results were also of a negative character.

Hunt,‡ by magnetizing an iron wire when formed in a circuit, and acted upon by an electrolyte, could not obtain any increase or decrease in the resulting current which could in any way be referred to the influence of magnetism.

In the majority of Professor Wartmann's experiments the chemical action, it will be observed, was excited by the electric current; now it is well known that if any circumstance should occur to affect the chemical action in one cell, the same influence would be felt throughout the whole of the circuit; hence arises an objection to this mode of proceeding. These remarks, however, cannot apply to those experiments in which he employed the voltameter.

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* *Loc. cit.*

† Bib. Univ., t. xxiii., p. 192. 1853.

‡ Phil. Mag., April 1848, p. 262.

In the following experiments we refrained from using the electric current as the exciter of chemical action, and employed the osmometer as the measurer of the chemical effect. The *electro-magnet* employed was that belonging to Professor Wheatstone. It is of the horse-shoe shape, consisting of a square bar of iron, each pole presenting a square surface two inches wide, four inches broad, and the space between the two poles is five inches. The coil of wire extends eleven inches up each arm, and within three-quarters of an inch from the top or end of the pole; the thickness of the coil being three-quarters of an inch, and composed of six separate wires.

Two osmometers were employed, and as far as possible identical, each consisting of an expanded bell-shaped glass vessel, an inch and a-half in diameter, an inch in depth at the centre, and capable of holding one ounce of fluid. The tube was one-eighth of an inch in internal diameter, roughly graduated, and twelve inches in length. The septum consisted of animal membrane tied tightly over the mouth. The jar containing the distilled water, or any other solution in which the osmometer was placed, was three inches in diameter and six inches deep, capable of holding twenty-two ounces of fluid.

To concentrate the line of magnetic force upon the osmometer two moveable poles were employed, each of soft iron two inches broad, two inches deep, and four inches and a-half long.

The *battery* usually employed consisted of six of Grove's cells, middling size, and occasionally twelve of Daniell's cells were added.

We must refer to Professor Graham's * valuable paper on

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* Phil. Trans., 1854. We soon, however, found that the cleanliness of the tube internally was of the utmost importance. It was always moistened with the same solution as that in the bulb, by passing some of the solution through it previous to every experiment.

Osmotic Force for further particulars in reference to the precautions necessary to be observed in judging of an osmotic result; and as our object on the present occasion was not to study the phenomena of osmose in all its particulars, but merely as a measurer of the chemical effects, we selected, in the first instance, those solutions only for experiment which appeared to present the greatest osmotic activity, such as the dilute solutions. For the purpose of ascertaining whether the *line of magnetic force* would influence the *osmotic action*, we employed the flat osmometer, having only one side, instead of the circular porous earthenware jar, as employed by Professor Graham in some of his experiments, so that the *line of osmotic action* should have a constant and definite relation to the *line of magnetic action.*

The *membrane* used in each osmometer was as far as possible identical, being taken off the same portion of gut, and soaked in the same water (which was changed once or twice), for twelve hours previous to being tied over the osmometer. Care was also taken to have the same surfaces exposed to the same solution.

The solution at first employed consisted of one drachm of liq. potassæ to eight ounces of distilled water. With this solution in the osmometer, and distilled water in the external glass jar, the osmose presented sufficient activity for our present purpose. The osmometer was suspended in the centre of the glass jar by means of strings, and the septum kept within the centre of *the line of magnetic force;* the two moveable poles being in contact with the glass jar, but kept from pressing too tightly upon its sides by means of wedges of wood. The other osmometer was prepared in the same manner, but kept out of the influence of the magnet.

It would be tedious, and moreover useless, to describe the numerous experiments that were undertaken and the results that were obtained, sometimes in favour of, and at other times opposed to, the conclusion that the result was in any way dependent upon the influence of magnetism. It is impossible to obtain two osmometers that would indicate identical results, and the want of a standard osmometer was sadly and early felt. We employed different acid solutions to obtain *negative* osmose. In some experiments an *acid* solution was employed on one side, and an *alkaline* solution on the other; and although the result of the experiment might appear at one time in favour of the osmometer placed in the magnetic field, nevertheless, upon carefully repeating the experiment, it ultimately vanished. We, however, ascertained the following important fact in reference to osmose: Thinking that the *position* of the *septum* in regard to the *line of magnetic force* might have some influence, and especially so since, in the experiments related in the previous section, the *rotation* occurred upon the *surface* of the magnet, we bent the tube of the osmometer so as to place the septum either *vertical* or *horizontal*, looking upwards, and not, as in ordinary osmotic experiments, looking downwards, and placed the septum sometimes just *outside* of the field of force. In our first experiments we were frequently led to believe that we had obtained some decided results, but they were ultimately explained away by considering that as the chemical action upon the membrane might occur, and be confined either to one side or the other, so would the position of the membrane enable the compound thus formed to separate and fall down, and so become more readily diffused in the liquids, allowing fresh particles to come into contact with the membranes to keep up the chemical action, and increase the osmotic action. As the effects occurred in both osmometers, we at first conjectured that terrestrial magnetism might have had some influence over the osmometer, which was not exposed to the influence of the magnet.*

It may, however, be urged, that in these experiments we have been confounding *osmotic* action with *chemical* action, and that although the former is greatly dependent upon the latter, nevertheless other circumstances are influential in producing *osmose* besides *chemical action*, and consequently we have not been dealing with a pure case of chemical action.

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* Professor Graham, in his first series of experiments (*loc. cit.*), used a porous circular jar for the osmometer, and in some of his subsequent experiments animal membrane. The earthenware osmometer was *vertical*, the other *horizontal*; and he appears to have obtained some results when using the former, which seem irreconcilable with those that he obtained when employing the latter. We may point out the binoxalate of potash and the sulphuric acid solutions as examples. May not the *position* of the septum have had some influence in producing these apparently contradictory results?

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To remove to a certain extent some of these objections, although they may still be urged, we used other septa, formed of coarse thick calico or of sail-cloth, and repeated these experiments. In these instances the osmotic action was not so great as with the animal membrane; in some instances it did not occur as it would have done with the membrane, but the variations were not so great; nevertheless, upon placing different solutions in the osmometer and in the glass jar, we could not obtain any result indicative of magnetic influence.

Similar experiments were undertaken with the large magnet belonging to the Royal Society. The magnet is composed of four hundred and fifty bar-magnets, each fifteen inches long, one inch wide, and half an inch thick, arranged in a box so as to present at one of its extremities two external poles. These poles projected vertically six inches from the box, were twelve inches broad, and three inches wide. They were nine inches apart. We thus had a field of *constant* force.* To concentrate the magnetic force we had two soft iron bars, each two inches and a-half broad, two inches thick, and twelve inches long. These were secured by means of strings or wedges to the extremities of the poles.

In this magnetic field we could place four osmometers, either with their septa all in the same position, or directed in four different positions in reference to the line of magnetic force. Great irregularity appeared in the results, even when the septa were all in the *same* position; the most constant results appeared when the septa were *vertical.* It will be unnecessary to detail the experiments, for in whatever *position* the septa were placed in regard to the *line of magnetic force,* whether in the *centre* of the field or on the *outside,* and whatever solutions were employed, the results were similar to those we had previously obtained with the electro-magnet. Tubes with larger bores were employed, and the osmometers allowed to remain for eighteen hours in the magnetic fluid, other similar osmometers being out of the influence of the magnet, yet we could not detect any difference either as to the *rapidity* of osmotic action, or even in its *amount*, indicative of *magnetic* influence. Differences were frequently observed, but these would occur whether the osmometers were in the magnetic field or out of it.

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* According to Faraday (Exp. Res., vol. i. p. 12) this magnet, when at Woolwich in the charge of Mr Christie, would support a force of nearly one hundred pounds. Upon trying its power when it first came into our possession, it would not support a weight of thirty pounds. This loss of power we attributed to the circumstance that the contacts between the various poles might have been greatly deranged during the conveyance of the magnet from one place to another.

From the results of the experiments that we have related in the previous section, it was reasonable to suppose that if the influence of magnetism was such as to produce motion of a mass of fluid, the power thus called into action might produce some, if not primary, at least secondary effect upon the resulting chemical action, perhaps increasing it by the removal of the compounds formed at the place of action, allowing fresh particles to come into play.

We were now led to the following experiments:

Two osmometers were formed in the following manner:—a cylindrical porous jar, one inch and a quarter in internal diameter, three inches and a half in depth, capable of containing two ounces of fluid, was fitted, by means of a cork, into the mouth of a glass jar, and made water-tight. The size of the glass jar was two inches and a quarter in internal diameter, five inches deep, and capable of holding about eleven ounces of fluid; but when the porous jar was fixed into it, it was then capable of holding about nine ounces of fluid. A narrow graduated glass tube was fitted, by means of a cork, into the bottom of the glass jar, the tube being bent at right angles; it was at this aperture that the osmometers were filled. The osmometer, thus arranged, was placed in a large glass jar, containing water or any other solution, the osmometer being entirely covered with the solution. One extremity of the bar of the electro-magnet was placed in the porous jar, as in former experiments, and, when acids were used, covered over with a cap of caoutchouc. The other osmometer was used in the same manner, having a similar iron bar placed in it, but unmagnetized. Even in this form of the experiment we have not been able to obtain any result indicative of the influence of magnetism (in its *static* condition) over osmose;

there was no increase or decrease in the osmometer containing the magnetized pole compared to that which contained the unmagnetized bar, or even without the bar. Variations in the osmotic result were frequently obtained, but they were similar to those which occurred when no magnet was employed, and such as we had already observed in former experiments.

These experiments having failed to give us any evidence that magnetism (in its *static* or quiescent condition) *increases* chemical action, confirming, therefore, the results of Wartmann, Grove, Matteucci, and perhaps others, it can scarcely be supposed that magnetism, under the same conditions, would *excite* or *originate* chemical action; but as experiments have been undertaken for the purpose of solving this question, we shall, in order to complete the subject of our inquiry, briefly refer to them.

§ III. *Does Magnetism (in its static or quiescent condition) excite or originate Chemical Action.*

"No attempt," says Faraday,* "to separate the perfectly mixed particles of any different substances has ever succeeded, though made with most powerful magnets. Oxygen and nitrogen differ exceedingly, yet no appearance of the least degree of separation occurred in very powerful magnetic fields. In other experiments I have inclosed a dilute solution of sulphate of iron in a tube, and placed the lower end of the tube between the poles of a powerful horse-shoe magnet, for days together, in a place of perfectly uniform temperature, and yet without the least appearance of any concentration of the solution in that end which might indicate a tendency in the particles to separate."

The following general conclusions may be deduced from the foregoing investigations:—

First, That *Magnetism* (in its *static* or quiescent condition), does not *excite* or *originate chemical action.*

Second, That when substances *undergoing* chemical action are submitted to the *influence* of magnetism (in its *static* or quiescent condition) *no increase* in the *chemical action* is observed; but that,

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* Faraday's Experimental Researches. *Series* xxv., *par.* 2757. Phil. Trans. 1851.

Third, Under certain conditions *during* chemical action, the influence of magnetism is such as to indicate a *directive* influence over chemical action; this influence being shown by a *rotatory motion* of the fluid around the pole of the magnet.

Fourth, That it is not necessary for the production of this *rotatory motion,* that the solution should act chemically *upon* the iron bar forming the pole; for, if the pole be surrounded by a metal ring, the *rotation* occurs, provided the solution is capable of *acting chemically* upon this metal ring.

Fifth, That the *influence of the magnet,* as well as the *existence* of the *chemical action,* and its *continuation,* are essential for the production of this *rotation;* and,

Sixth, That the *direction* of the *rotation* is dependent upon the *poles* of the magnet, being *contrary* for each *pole.*

Contributions to Ornithology. By Sir W. JARDINE, Bart.

No. IV.

Another small ornithological collection from the western slope of the Andes has arrived from Professor William Jameson of Quito. A second specimen of *Saltator arremonops* has been received; and *Tetragonops ramphastinus* has again also been obtained, although not in time to accompany the birds now sent. This last bird "inhabits the deep recesses of the forests on the western flank of the Cordillera. It utters a loud note, the sound of which resembles the baying of a deer-hound; hence '*Venadero*' (a deer hound), the name by which it is known to the natives. From the echoing sound, one would imagine that it proceeded from a bird of much larger size."

Among the birds which we have not previously received from the western side of the Quitan Andes are one or two of some interest.

Thamnophilus immaculatus (Lafresn.)—A specimen of a *Thamnophilus* occurs closely allied to the bird described by Mr Sclater (*Ed. New Phil. Jour.* i. p. 249) under the above name. The carpal joint of the wing has a patch of white, as there described, formed partly by some of the lesser wing-covers being white at the base, and by the feathers which spring from the body immediately at the insertion of the wings having similar markings. The dimensions of our specimen also correspond nearly; and although the length appears greater, it cannot be depended on in a skin, and we could not venture to place the two birds as distinct without a comparison. Length of the skin, 7·5; wing, 3·3; bill to extremity of rectus, 1·2.

Momotus semirufus (Sclater); *Rev. and Mag. de Zool.*, p. 489, 1853.—A rare species of Momot belongs to the group, which have no ornament or bright colouring upon the head; and is at once distinguished from the other brown-headed birds, by the entire head, nape, sides of the neck, chin, throat, breast, and belly, being clear and bright sienna, interrupted only by the deep black of the auricular feathers, the latter colour stretching also in front of the eye to the nostrils (but without forming any frontal band), and at the lower part on the base of the mandible; both eyelids are black. The other upper parts of the plumage are of the usual yellowish-green; the outer webs of the black quills bright blue; the vent and under-tail coverts bluish-green. Length, 17; wings, 5·8; bill, to extremity of gape, 2·2. The edges of the mandibles broken, but not regularly notched.

Mr Gould possesses another skin, marked "Quito," obtained from a collection in that country, and in all probability procured not near Quito, but from the same locality with our own.

There is a specimen of the very beautiful and curious form, *Eurypyga*. It is from the forests on the same western flank of the Andes, where it builds on trees by the sides of the mountain rivers. The young has the nestling plumage of the rails, but appears very soon to assume the painted markings of the adult. From the structure of the plumage in this state we would judge that the young were capable of running and making their own way immediately after hatching; but we hope ere long to have a satisfactory account of their habits and incubation.

The nest of *Trochilus gigas* is a much more solid structure than that of the humming-birds generally, though these birds commonly collect and gather together a mass of materials very large in comparison to their size and strength. The diameter of the nest is a little above three inches, its solid perpendicular height about four. The base is strongly compacted together, and strengthened with clay, so as to be of a weight that will require more than the usual support. The upper or nest portion is composed of fine mosses, bound and felted together with the woolly fibres taken from some of the down-covered plants which are not uncommon in these regions. It is altogether a solid and warm structure.

Correlation of the Triassic Rocks in the Vale of Worcester, and at the Malvern Tunnel. By the Rev. W. S. Symonds, F.G.S.

1. Upper Grey Red Marls,	Keüper.
2. Keüper Sandstone,	
3. Lower Red Marls,	
4. Waterstones,	
5. Upper Red Sandstone (Bromesberrow Beds),	Bunter.
6. Lower Red Sandstone (Red Rock of Malvern),	

The above represents the order of the triassic rocks in the valley of the Severn, in the Malvern and Worcester districts, now rendered especially interesting by the escarpments laid open in the tunnel of the Worcester and Hereford railroad, near the "Admiral Benbow," at Malvern Wells.

No. 6. Lower Red Sandstone.—During the excavations for the foundation of the residence of the Messrs Burrow, near the Bellevue Hotel, at Great Malvern, a dark red sandstone, with black markings of the protoxide of manganese, was exposed, resting against the syenite of the hill, covered up by a thick accumulation of debris, and dipping at an angle of 60° to the south-east. A remarkable erratic block, weighing some hundreds of pounds, angular at the edges, and with no sign of subaqueous action, was found imbedded in the mass of red sandstone. This block consists of the same "Cambrian" rock as the angular Permian breccias of Haffield Camp, and thus favours the Permian glacial theory of Professor Ramsay. The red sandstone, thus curiously exposed at a considerable elevation, and flanking the Plutonic chain of the Malverns, differs considerably in mineral character both from the "Waterstones" and the Bromesberrow beds; I am therefore inclined to place it with the "Lower Red Sandstones" of the geological surveyors, which are developed higher up the Severn valley in the Stourport district. However this may be, the position of this red rock, when compared with the position of the Upper Keüpers in the Malvern tunnel, is very striking, as proving a considerable elevation of the Plutonic and Syenitic range, between the deposition of the Lower Red Sandstone (No. 6) and the deposition of the Upper Keüper Marls (No. 1).

No. 5. *Upper Red Sandstone* (Bromesberrow Beds).—In the Malvern district, the Permian breccias are covered up by a soft red sandstone, well displayed in the parish of Bromesberrow, at the southern extremity of the range. It is necessary to warn the geologist against confounding these beds with the "Newent sandstones," or "Waterstones," of the geological surveyors. They are a LOWER SERIES of strata, as may be seen on working out one or two puzzling sections between the valley of the White-leaved oak and Haffield Camp, at the southern extremity of the Malvern range. The relation of these beds with the "Waterstones" may also be seen at Blakedon Hill, near Leamington, as described by Sir R. Murchison and Mr Strickland; and they are exposed at the base of the Grinshill quarries, eight miles from Shrewsbury.

No. 4. *Waterstones* (Newent Sandstones).—An interesting MORSEL of these deposits flanks the Chase End Hill of the southern Malverns, at the back of the Hawthorns, on the Bromesberrow road. The working out of the relation of these rocks with the Lower Keüper marls and the Bromesberrow sandstone requires some care, and may be best carried out at this point; and again, along the Glynch brook, for the fault from Bromesberrow below Red Marley is extremely puzzling. The lower "Waterstones" are well developed in the neighbourhood of Red Marley D'Abitot, Pauntley, Oxenhall, and Newent. The upper strata are GREY SANDSTONES, passing into yellowish-red beds; the lower beds are exposed in most of the narrow lanes of the Red Marley and Newent Ryeland district, but the upper grey beds are mostly denuded. An outlier, however, is still left near the church of Red Marley D'Abitot, and the church was rebuilt in 1855 with excellent stone from the quarries near. These grey sandstones are, I believe, the equivalents of the celebrated Grinshill sandstones, and the grey beds of Ombersley and Bell Broughton in this county. I visited the Grinshill district last autumn, under the guidance of the well-known naturalist, Mr Eyton of Eyton Hall, who directed my attention to a small trap dyke which alters the Waterstones in contact into a quartzite rock. We saw an interesting specimen of the "Rhynchosaurus" in the possession of a shopkeeper, who refused to part with it. Many of the slabs were ripple-marked, and retained the impression of raindrops on their surfaces. It was interesting to find my Red Marley friends so persistent in lithological character, yet so wonderfully increased in importance and development.

No 3. Lower Red Marls.—These marls are principally remarkable for their salt springs worked at Droitwich and Stoke Prior, where they have been penetrated to the depth of 600 feet. They are seen to dip under the Keüper sandstone at many localities east of the Malverns. In the railroad tunnel they rest against the Syenite, and dip at an angle of 53° to the south-east. At the point of contact they are much crushed and broken, but without a symptom of metamorphism; in some places they are arched and contorted, and must have been in a plastic state when upheaved. Only a few feet of these lower marls are elevated and exposed. A brine spring was lately tapped at the Asylum near Powick, four miles from Worcester, proving the extension of the salt.

No. 2. Keüper Sandstone.—These grey sandstones have also been cut into, they dip away from the Syenite, resting against the lower marls, at an angle of 50°, and are identical in mineralogical character with the Keüper sandstones of Burghill, Longdon and Pendock; they are succeeded by the upper grey and red marls.

No. 1. Upper Grey and Red Marls.—These beds afford especial interest in the section of the Malvern tunnel. At the mouth of the present opening they exhibit nearly horizontal layers of strata covered by Malvern syenitic debris; allowing for a slight dip, they correspond with the plane of the upper marls of Crowle, the Berrowhill, Sarnhill, and other rounded outliers of the vale, but on proceeding up the tunnel a grand fault is exhibited, for many feet of red and grey strata that graduate towards the Keüper sandstones exhibit the high dip of the lower beds, thus proving to an extreme exactitude one period of an elevation of the syenitic ridge. A little beyond the tunnel mouth the upper marls are cut off by denudation.

It is impossible to study the sections displayed in the works of the tunnel without reflecting on the truthfulness of former geological theories entertained by our most distinguished geologists, as respects the history of the deposition of our Triassic rocks, and the *periodical* and *gradual* upheaval of the Malvern range.

On some Species of Corals in the Lias of Gloucestershire, Worcestershire, Warwickshire, and Scotland.

By the Rev. P. B. Brodie, M.A., F.G.S., Vice-President of the Warwickshire Naturalists' Field Club, Hon. Secretary and Hon. Geological Curator of the Warwickshire Natural History and Archæological Society.

My object in the present paper is not to attempt a scientific description of the Liassic corals, which I hope, may be done by some palæontologist better acquainted with them, but rather to note the discovery of some species which appear to be new in the Lias, and to point out the position in which they occur. Very few have been described in this country, and therefore it seemed desirable to draw the attention of geologists interested in the subject to those which have been more recently brought to light. As a general rule, fossils of this kind are not common in the Lias, the sea in which it was deposited being unfavourable to the growth of polyparia. though in some localities they are not so scarce as has been generally supposed. In the upper Lias, the only specimens with which I am acquainted are the *Thecocyathus Moorii* and *T. primus*, belonging to the family Turbilonidæ, found by my friend Mr

Moore near Ilminster, and figured and described by Milne-Edwards and Jules Haime, in the Memoirs of the Palæontographical Society for 1851, and also a small undescribed species of Cyathophyllum, and a Flustra from the same bed. Mrs Hugh Strickland was kind enough to send me a sketch of the upper portion of a large lamellated coral, found by my late lamented friend, Mr Hugh Strickland, in the Lias marlstone at Byfield, in Northamptonshire. It is a simple turbinated coral, probably belonging to the family Fungidæ. In the lower Lias, a few corals have been met with in the clays and shales near Cheltenham (which may evidently be assigned to the genus Montlivaltia), in the same bed as that which contains *Pleurotomaria Anglica* and other fossils. I found three perfect specimens, though of small size, at Down Hatherley, between Cheltenham and Gloucester. A similar genus was obtained by my friend Mr Gavey, at Moreton in the Marsh, and another, and perhaps a different species, beautifully preserved, occurs in the same beds of Lias shale, at Fenny Compton, in Oxfordshire, where the presence of a species of Turbinolia ? (probably a Montlivaltia) is noticed by Conybeare and Phillips in their "Geology of England and Wales." Milne-Edwards, in the monograph on fossil corals above referred to, speaks of the cast of a Montlivaltia in the lower Lias near Bath, in the collection of Mr Walton. All those I have seen of this genus are small, round, turbinated corals, and one or two show the point of attachment. They do not however, appear to be referable to more than two species, and single individuals are not abundant. Through the kindness of Miss Slinger of Cheltenham, I fortunately obtained another small coral, which I take to be a species of Turbinolia. It was found in the shales of the lower Lias, with *Spirifer Walcotii*, and other shells, and it has a minute Flustra attached. On the surface of the blue limestones, containing *Lima gigantea, L. rudis,* and *Ostrea,* I detected a small coral, distinct, I think, from the rest, and identical, possibly, with a smaller one in the cabinet of Mrs Hugh Strickland, from the lower Lias of Abbott's Wood, in Worcestershire. There is a stony, shelly band of Lias, seen at Down Hatherley, Bushley, and other places, full of *Cardinia ovalis* and *C.*

Listeri, a few inches thick, which contains a small branching coral in some numbers; unfortunately the surface of the stone is much water-worn, and the corals are, in consequence, considerably eroded.

This stratum is particularly interesting, from the occurrence of numerous minute Foraminifera, which have every appearance of true "*Nummulites*," described by Mr Rupert Jones, and referred to by myself in a short paper "On the Lias of Fretherne Cliff, below Gloucester," read at a meeting of the Cotswold Naturalists' Club* in 1853, and since published in Taylor's "Annals of Natural History." Many other fossils, especially a variety of little univalves, are associated with them. In the same bed at Purton Passage, on the opposite side of the Severn, a small specimen of Isastrea was obtained, and I lately procured a remarkably fine coral of this genus from the equivalent stratum at Inkberrow in Worcestershire,† where the Lias joins the Keüper, close to the line of fault which traverses that district. Only a few have been met with, but sufficient to show that they formed part of a small reef of Astreidæ, and are not mere isolated individuals, as most of the Liassic corals seem to be. They were found along a narrow ridge in the *Cardinia bed*, in a grass meadow which had not been ploughed up for many years, so that it was impossible to detect the corals *in situ*, though there can be no doubt of their exact position; they are more numerous than in any other locality, except perhaps in Scotland. The specimen in my possession is a massive, stony, calcareous coral, measuring 1 foot 5 inches long, and 5 inches broad in the widest part, and shows the upper and under surface in tolerable perfection. I was aware of the existence of a species of Isastrea in the Lias several years ago, as a few have been procured from a clay-pit near Evesham, about 10 miles from Inkberrow. They were stated by the workmen to occur at the bottom of the pit in the clay, 40 feet below the surface, and not exactly in the same position as those at the latter place. The specimen in my cabinet, however, belongs to the same species as the ones found at Purton and Inkberrow, and is a solid, stony mass, but much better preserved; in some, the cells are soft and crumbly, and not at all solidified, very different from the condition of the majority of Isastrea. In order to compare this species with the one found at Lustra, in the Isle of Skye, I obtained, through the kindness of Mr Archibald Geikie, of the Scotch Geological Survey, a specimen of those fine corals which have been already noticed by Sir R. Murchison and the late Mr Hugh Miller,* and are abundant there in the lower division of the Lias. Mr Geikie informs me that they "vary considerably in size, ranging from about three or four inches to more than a foot in length. They are generally oblong, and a good deal flattened, and sometimes lumpy on the surface, the cells covering, as it were, the inequalities of an inner surface." The one I have displays the coralline structure well, but not better than those from the neighbourhood of Evesham, and belongs, apparently, to a different species. The bed in which they lie, Mr Geikie states, is irregularly two feet thick, and is composed entirely of these Isastrea, cemented together in a hardened mud. They are piled together in masses, one above another, without the admixture of any other fossils. The thickness of the Skye Lias is at least 1200 feet, and, as the *Gryphæa incurva* occurs 100 feet above the Coral bed, it would seem to come very near the horizon of the Isastrea beds in England. In some bands of hard white limestone in the lower Lias, rather low down, I think, near Leamington, in Warwickshire, I have obtained four or five small corals, most nearly resembling the coral from the marlstone in Northamptonshire. There is a similar species in the white Lias, near Southam, and elsewhere in the same county, but higher up in the series. It is worthy of remark, that in places the Lias in Warwickshire assumes a peculiar lithological character, differing in many respects from the equivalent strata in Gloucestershire. This is particularly observable at Newbold, near Rugby, where there is a thin layer of limestone, almost green in colour with Ostrea and spines of Echinoderms, and a soft, white, crumbly stone, unlike any Lias I have seen elsewhere. Much iron pyrites is diffused throughout the mass. I hope hereafter to describe these and other remarkable beds of Lias in Warwickshire.

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* Proceedings of the Cotswold Naturalists' Club, vol. i., p. 241.

† My attention was first drawn to this locality by my friend Mr Chattock, on whose estate the corals were discovered.

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* Edinburgh New Philosophical Journal, New Series, vol. i., p. 366.

These are all the Lias corals with which I am acquainted in the British isles, though possibly a few may be buried in private collections. I hope, however, this notice of those which have come under my cognisance may be the means of bringing any others to light, and of inducing some one who has made this branch of Palæontology his study, to describe the whole in detail. A few years since, my friend Professor Buckman sent up some Liassic corals to the late Professor Forbes, but they were unfortunately lost before any description had been given of them; but Professor Buckman thinks that most of them were identical with those above described.

On the Continent, some corals have been met with in the upper Lias at Calvados, in France; and two species of Isastrea and two species of Montlivaltia, are figured and described by M. Chaperis and Dewalque,* from the lower Lias in France and Belgium, in beds which occupy a similar position in the series to those near Cheltenham. The Montlivaltia differs from the species in my collection, but I cannot speak so decisively with respect to the Isastrea.

The Chemistry of the Iron Manufacture of Cleveland District. By William Crowder, F.C.S., Newcastle-on-Tyne.

The present communication is intended to form the commencement of a series of investigations into the various stages of the manufacture of iron, more particularly as pursued in the neighbourhood of Cleveland.

On two previous occasions, I have communicated to the Edinburgh New Philosophical Journal the results of an extensive series of analyses of the ironstones obtained from the different mines in that locality, and in adjoining districts; and I have been naturally led so far to extend the inquiry as to embrace the investigation of the various stages of smelting and refining these ores.

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* "Description of Secondary Fossils of Luxembcurg," Pl. 38, f. 8.

The subject is one surrounded with great difficulties, partly because we are unable to trace the operations through every stage of their progress, and can only judge of what has occurred by the ultimate result;— partly from the necessity of taking into consideration the numerous complicated conditions required to bring about a given result;—partly on account of the difficulty of collecting some of the products; and last, though by no means least, because of the difficulty and minuteness required in many of the analyses, and the series of tedious repetitions necessary before any safe conclusions can be deduced.

The operations of the iron manufacture are twofold:—

1st, The smelting or reduction of the ore, with the production of crude or cast-iron.

2d, The conversion of crude into wrought or finished iron.

The present, and one or two future communications, will have reference to the first of these operations, viz., the smelting of iron.

On reflecting for a moment upon the construction of a blast furnace, it will be evident that there are two exits for the products of the changes that have taken place in the interior, viz., at the tunnel-head and at the hearth. At the former will escape all the gases generated inside, together with any solid matters capable of volatilization by intense heat; at the latter, all the solid matters which are non-volatile will escape in a melted state. If, therefore, we collect the solids from the hearth, and the gases and volatilized matters from the tunnel-head, we have an expression of the ultimate effect of the chemical operations that have gone on inside.

It matters little whether we commence our experiments at the hearth or the tunnel-head; but for convenience we have devoted our attention, *firstly*, to the products from the hearth.

The products from the hearth are of two kinds; there is—

1st, The slag, produced by the combination of the various impurities contained in the ironstone, and the ashes of the fuel with the limestone used as flux; and,

2d, The crude iron, combined with various small quantities of impurities, which latter determine the quality of the preceding in a remarkable degree.

If we desire to obtain the explanation of the composition of the products *obtained* from the furnace, an accurate knowledge of the composition of all the materials *introduced* must be presupposed, else no intelligible equation can be given.

Hence, in the first instance, a complete investigation into the composition of all these materials becomes necessary.

Having established the composition of all the ingredients with which we start, it next becomes important to detail the various quantities which are mixed together to produce a given result; and if, after subjecting these materials to the process of reduction, we now weigh and then analyse the various products, we ought to get a complete quantitative expression of the mode in which the various matters have been disposed of.

So far as theory goes this is quite correct; in fact, we might regard the operation of a blast furnace in the same manner as an assay on a gigantic scale. Unfortunately, however, the command of uniform conditions is in most cases impossible, principally on account of the variable composition of the calcined stone. It will be evident to persons acquainted with the process of iron-smelting, that it is exceedingly difficult to insure complete or uniform calcination. If this is not accomplished, the proportion of volatile matters remaining behind interferes, more or less, with the accuracy of the result, depending upon the extent to which the operation has been actually carried. All, therefore, that we can accomplish is to ascertain what result is *practically obtained.*

Again, if we collect the solid products at regular intervals *between* one tapping-time and another, upon analysis these products ought, by their composition, physical appearance, and properties, to indicate any changes, however minute, that have gone on inside the furnace since the previous specimen was taken.

It is quite true that these fluctuations cannot be relied on by a few analyses; but when an accumulation of results of this kind, obtained under every variety of condition, and in different furnaces, are compared together, any *constant* change can be easily noted.

In the present investigation I have, as far as circumstances admitted, endeavoured to follow out the course indicated in the preceding remarks, in the hope that the results obtained may prove of some value as a trifling contribution to our present imperfect knowledge of the theory of iron-smelting.

The present paper contains three distinct series of experiments; the first two being the results obtained from the furnaces of Messrs Cochrane & Co., Ormsby Iron-works, Middlesboro'; the third series being from those of Messrs Bell Brothers, Clarence Iron-works, Middlesboro', to both of which firms I am much indebted for the assistance they have so kindly rendered me in my investigations.

The FIRST SERIES, from Messrs Cochrane & Co., contains the results of analyses of two sets of slags, taken respectively on the 20th and 22d of May, from No. 1 furnace, producing Nos. 1 and 3 iron; the other two sets from No. 2 furnace, taken respectively on the 27th and 29th of May 1856, when the furnace was on mottled iron.

The SECOND SERIES, from Messrs Cochrane & Co., contains the results of experiments made on Nos. 1, 2, and 3 furnaces, in August 28, 1856, when on No. 2, and mottled iron, and No. 1, respectively.

The THIRD SERIES contains the results of experiments at one of Messrs Bell Brothers' furnaces, when on foundry iron.

In detailing the method adopted in making the analyses, it will be unnecessary to enter more fully into a description of the ironstone analysis than to state that the examinations were conducted in an exactly similar manner to those in my last investigation. The iron was in all cases determined by permanganate of potash.

Method adopted in the Analysis of the Slags.

A quantitative analysis of the slags gives the following ingredients:—Iron, alumina, lime, magnesia, manganese, potash, soda, silica, sulphur, sulphuric acid, phosphorus or phosphoric acid.

The finely powdered material was digested with hydrochloric acid, by which it is decomposed, with the production of a mass of gelatinous silica, it was evaporated to dryness, and redissolved in acid.

The operation was effected much more rapidly by heating on a water-bath, since, by using these means, there is not the tendency to bumping, and consequent loss by projection of portions from the dish, as is experienced when a sand-bath or naked gas flame is used. Sulphuretted hydrogen was invariably evolved in this operation.

After redissolving in acid, the silica was filtered off, and chlorine water was added to the hot solution, and then ammonia, by which iron, alumina, manganese, and phosphoric acid are precipitated; this was well washed with boiling water, dried, and weighed. It was then dissolved in hydrochloric acid; some tartaric acid was added, and then ammonia and sulphide of ammonia. This throws down iron and manganese, leaving alumina in solution; by reprecipitating the iron and manganese with chlorine and ammonia, and filtering, they may now be weighed together as $Mn_3\,O_4$ and $Fe_2\,O_3$. By determining the quantity of iron present with a very weak solution of permanganate of potash, and deducting it from the weight of the two bodies, the quantity of manganese is obtained. The manganese was also frequently determined by boiling with perchloride of iron and acetate of potash, when the phosphoric acid remains as a precipitate, and the manganese passes through. Since it was found practically that traces of iron and alumina passed through along with the manganese, some tartaric acid was added to the filtrate. Sulphide of ammonia and ammonia precipitated iron and manganese. The manganese was then determined as before.

It was not considered necessary to determine the manganese in every instance, but a sufficient number of cases have been given to show the general proportion of this constituent. Alkalies were determined in the usual manner with baryta. One determination for each set was considered sufficient.

Lime and magnesia were determined in the usual manner. *Sulphur* was determined by digesting the slag in red fuming nitric acid, evaporating to dryness, and redissolving in *hydrochloric acid.*

Great care was taken in these determinations. The nitric acid was purified by distillation with a small quantity of nitrate of baryta, to insure the absence of the last traces of sulphuric acid. A considerable quantity of the distilled acid was evaporated to dryness in a glass beaker, with some nitrate of baryta, and the residue was treated with boiling water. The whole dissolved without leaving even traces of sulphate of baryta, *showing the purity of the nitric acid.*

It having been lately shown by Noad and others that sulphate of baryta is slightly soluble in nitric acid, the precaution of taking up with *hydrochloric acid* was observed; and the close correspondence of the results seems to confirm the accuracy of the plan.

There is invariably present small quantities of sulphuric acid, amounting to from 0·10 to 0·30. As this quantity was so small, the examination for that ingredient was usually omitted, and the whole of the sulphate of baryta obtained calculated into sulphur.

Phosphoric acid was determined by the acetate of potash and perchloride of iron method.

There is great reason to believe that the phosphorus exists as such in the slag, and not as phosphoric acid; for, in looking over the analysis, it will be seen that after adding the quantity for alkalies, the analyses almost invariably come too high. I have therefore calculated it as monophosphuret of calcium $= Ca\,P$. It is quite possible that the phosphuret may contain more than one equivalent of calcium, in which case the analyses would come still closer to the 100 parts.

In a few cases the mode of decomposing the slag was by fusion with carbonate of soda; but the results obtained by this method being the same as when hydrochloric acid was used, only a few experiments were conducted by this plan.

Analysis of the Cast-Irons.

The major portion of the iron dissolves in dilute hydrochloric acid, the remainder consists of silica, lime, alumina, magnesia, and graphite. Twenty-five grains were dissolved in dilute hydrochloric acid. The insoluble matter was thrown on to a weighed filter, and after obtaining the weight of the residue, it and the filter were burned in a platinum crucible. A small quantity of nitre and carbonate of soda was mixed with it, and the whole fused. It was then dissolved in acid, evaporated to dryness, and taken up with acid, the silica filtered off, and the iron, alumina, lime, and magnesia determined. The sum of these constituents deducted from the weight of the residue insoluble in acid gives the quantity of graphite or uncombined carbon.

In the determination for graphite, a small correction must be made, since the silica in the insoluble residue, when dried at 212°, is a hydrate, the water of which must be taken into account. This was observed in every case.

The portion *soluble* in dilute acid was evaporated to dryness, and redissolved in acid, to separate any soluble silica, the iron in the liquid was peroxidized with nitric acid; carbonate of soda and acetate of potash were then added, and the manganese, lime, and magnesia passes through the filter. The manganese was thrown down (after concentrating the filtrate) by hypochlorite of soda, and the lime and magnesia in the filtrate, or the manganese was precipitated by sulphide of ammonium, redissolved, and precipitated by carbonate of soda. The manganese was all in the soluble portion.

Sulphur.—Similar precautions were observed in examinations of sulphur as in the analysis of slags, with regard to the solubility of the sulphate of baryta in nitric acid.

Twenty grains of the finely-powdered iron were dissolved in perfectly pure nitric acid, which had previously been distilled with nitrate of baryta. It was then evaporated to dryness, and taken up with pure hydrochloric acid, and the sulphuric acid determined with nitrate of baryta.

Phosphorus was determined in the filtrate by boiling with acetate of potash and chloride of iron.

The precaution of deoxidizing the greater portion of the iron with sulphate of soda was invariably observed, by which means we were enabled to obtain the phosphoric acid combined with only two or three grains of peroxide.

Carbon was determined by combustion with chromate of lead and chlorate of potash, at times assisted with a small quantity of chromate of potash. By deducting the quantity of graphite found in the portion insoluble in acid, the difference was the quantity of combined carbon.

Materials used in the Experiments.

Ironstone.—The stone, as I have already indicated in my previous papers, is a carbonate of protoxide, yielding, by analysis, on an average about 30 or 31 per cent. *metallic iron* in the raw state. As, however, the stone is calcined before introducing it into the furnace, a corresponding increase to the percentage of loss by heat must be made. Six samples were selected and analysed, the results of which were published in my last paper. It will therefore suffice to take the average of these six analyses, and side by side to append its composition in the calcined state. This refers to the first series of experiments, viz., those performed in May.

Calculated average composition of six specimens of Hutton stone from Messrs Cochrane's works, May 1856, raw and calcined.

	Raw.	If Calcined. (Calculated.)
Silica,	14·35	19·77
Peroxide of iron,	44·50	61·32
Alumina,	4·92	6·78
Lime,	4·03	5·55
Magnesia,	2·18	3·00
Phosphoric acid,	2·21	3·00
Sulphur,	0·27	0·37
Sulphuric acid,	0·11	0·15
Loss by heat,	27·43	...
	100·00	99·98
Metallic iron,	31·15	42·90

In the *second* series of experiments, performed at Messrs Cochrane & Co.'s works in August, the calcined stone was *analysed*. In order to procure an average specimen, several hundredweights of the ore from the clamps were crushed to a coarse powder, the whole was then thoroughly mixed together, and a pound sample taken.

The whole of this pound was then ground in the laboratory to a much finer powder, and sifted, and from it the quantity for analysis was drawn.

Analysis of Calcined Hutton Stone.

Silica, ...	16·50
Alumina, . . .	15·03
Peroxide of iron, . .	53·40
Protoxide of manganese, . .	0·25
Lime, ...	8·40
Magnesia, . . .	3·90
Sulphur, . . .	0·31
Phosphoric acid, . .	2·32
Sulphuric acid, . . .	1·33
	101·44
Metallic iron, . . .	37·38

In the *third* series, performed at one of Messrs Bell Brothers' furnaces, the ironstone was from their mine at Normanby. It was calcined, and was taken from a very large quantity, and ground fine, as in the preceding case.

Analysis of Normanby Stone.

	Calcined.	Raw Stone calculated into Calcined.
Silica, . . .	21·00	17·32
Alumina, . .	10·12	8·17
Peroxide of Iron, .	52·68	56·18
Protoxide of Manganese, .	0·30	1·15
Lime, . . .	4·45	9·19
Magnesia, . .	3·23	5·41
Sulphur, . .	0·13	0·36
Sulphuric acid, . .	1.05	trace.
Phosphoric acid, . .	1·70	1·66
Moisture and Carbonic Acid,	5·34	...
	100·00	99·97
Metallic iron, . .	36·88	39·32

Hæmatite.—Along with the previously named ironstone, there was invariably used a certain quantity of Cumberland hæmatite.

As this is used only sparingly, and as the composition of the masses is pretty uniform, it was not deemed necessary to take such great precautions in the grinding of a large quantity. The following were the results obtained by subjecting the different kinds to a chemical analysis:—

Analysis of Cumberland Hæmatites.

	Kidney.	Compact Masses.	The Small.
Silica,	1·50	10·20	12·30
Peroxide of Iron,	98·00	89·20	86·00
Lime,	Trace.	Trace.	Trace.
Magnesia,	...	...	...
Sulphur,	Trace.	Trace.	Trace.
Phosphoric acid,	0·34	0·32	0·30
Water,	...	...	1·90
	99·84	99·72	100·50
Metallic iron,	68·60	62·44	60·20

Average of the three specimens, 63·74 per cent. metallic iron.

Limestone.—The limestone used in the experiments at Cochrane & Co.'s was from Frosterly. It is nearly pure carbonate of lime, free from any considerable quantity of silica, sulphur or phosphoric acid. The analysis was as follows;—

Analysis of Frosterly Limestone.

Silica,	0·60
Oxide of iron and alumina,	0·50
Lime,	54·65
Magnesia,	0·55
Carbonic acid,	42·99
Sulphuric acid,	0·50
Water,	0·13
	99·92

The limestone used at Messrs Bell Brothers' had the following composition:—

Silica,	1·50
Oxide of iron and alumina,	0·85
Carbonate of magnesia,	4·41
Carbonate of lime,	93·24
	100·00

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Coke.—The fuel used in this district is invariably coke, which is in consequence manufactured in enormous quantities, to supply the furnaces.

That which was used in the present experiments was a fine hard coke, and bears a good name amongst iron-smelters. It is also largely used for locomotive purposes.

Analysis of Coke.

Carbon,	89·70
Silica,	4·43
Alumina,	1·92
Sulphuret of iron,	2·07
Sulphuret of calcium,	1·10
Sulphuret of magnesia,	0·50
Phosphoric acid,	0·28
	100·00

The first specimens of slag for analysis were collected about three or four hours after the last casting, *i.e.*, at 9 o'clock in the morning; at this time the slag *begins* to run over the notch. It was again collected at 12 o'clock, and again at 5 o'clock P.M., just before casting.

It was also collected at times after the iron was run off, since a film of slag of some depth lies immediately on the top of the molten iron, and *below* the notch, consequently this portion runs out *through the tapping-hole*, after the iron is cast, and not by the notch at all. It was thought possible that this "Roughin," as it is technically termed, might differ from the other portion of the slag to some extent, both in its physical and chemical properties. It would be probably denser, and was generally more crystalline, than the slag run at an earlier hour.

The iron taken for analysis was from chips off an average pig, run at 5 P.M.

The pulverization of the iron was effected in a steel mortar, and the resulting powder sifted through a fine sieve.

As the graphitous scales are liable to separate from the iron in flakes, great care must be taken to insure their uniform admixture through the powder.

(*To be continued.*)

On the Physical Geography of the Tertiary Estuary of the Isle of Wight. By H. C. Sorby, F.G.S. (Plate IV.)

In the following communication on the Tertiary deposits of the Isle of Wight, I shall bring to bear facts and general principles that have hitherto attracted very little attention. In my papers on the Physical Geography of the Old Red Sandstone sea of the Central District of Scotland, and on the Terraces in the Valley of the Tay, north of Dunkeld, published in this Journal,* I have described these to some extent; but since, in the subject now before us, the points of importance differ very materially from those then in discussion, it will, I think, be better to reiterate some of them, in order to bring the essential facts more prominently into view.

It appears to me that the physical structure, as well as the organic remains, of the fluvio-marine tertiaries proves that they were formed in an estuary at the mouth of a large tidal river. The chief currents that are present in such a case now are those due to the rise and fall of the tide, the stream of the river itself, and the action of the surface-waves on the coasts and shoals. Those caused by the tide are characterized by moving up and down the estuary as it rises and falls; the direction of this line of oscillation of the current in different parts depending on their configuration. Near the coasts or shoals it is nearly parallel to them; but in intermediate positions it coincides with the resultant axis for the locality. The river-stream follows much the same laws as the out-stream of the tide, and acts as a force to be added to it, and subtracted from the in-current due to the rising tide. These facts necessarily result from the general laws of hydrodynamics, in the same manner as the current down a river must, on an average, be parallel to its banks; and are well known to mariners, being constantly alluded to in "sailing directions" for their use. Some of them are also most completely borne out by the actual observations of Captain Beechey, as published in the Philosophical Transactions for 1848 and 1851; and I would particularly call attention to the directions of the currents in the Bristol Channel, as given in the maps accompanying the latter paper. In proof of the rest, I refer to the excellent and most instructive chart of England and Holland by Norrie, particularly to the mouth of the Thames; where, however, the arrows indicate only the current of the rising tide. Now, if the organic remains in the fluvio-marine tertiaries of the Isle of Wight indicate that the deposits were formed at the mouth of a great river communicating with the sea, if it was affected with tides, it appears to me to be only strict induction to conclude that the same laws would apply to the currents present in it.

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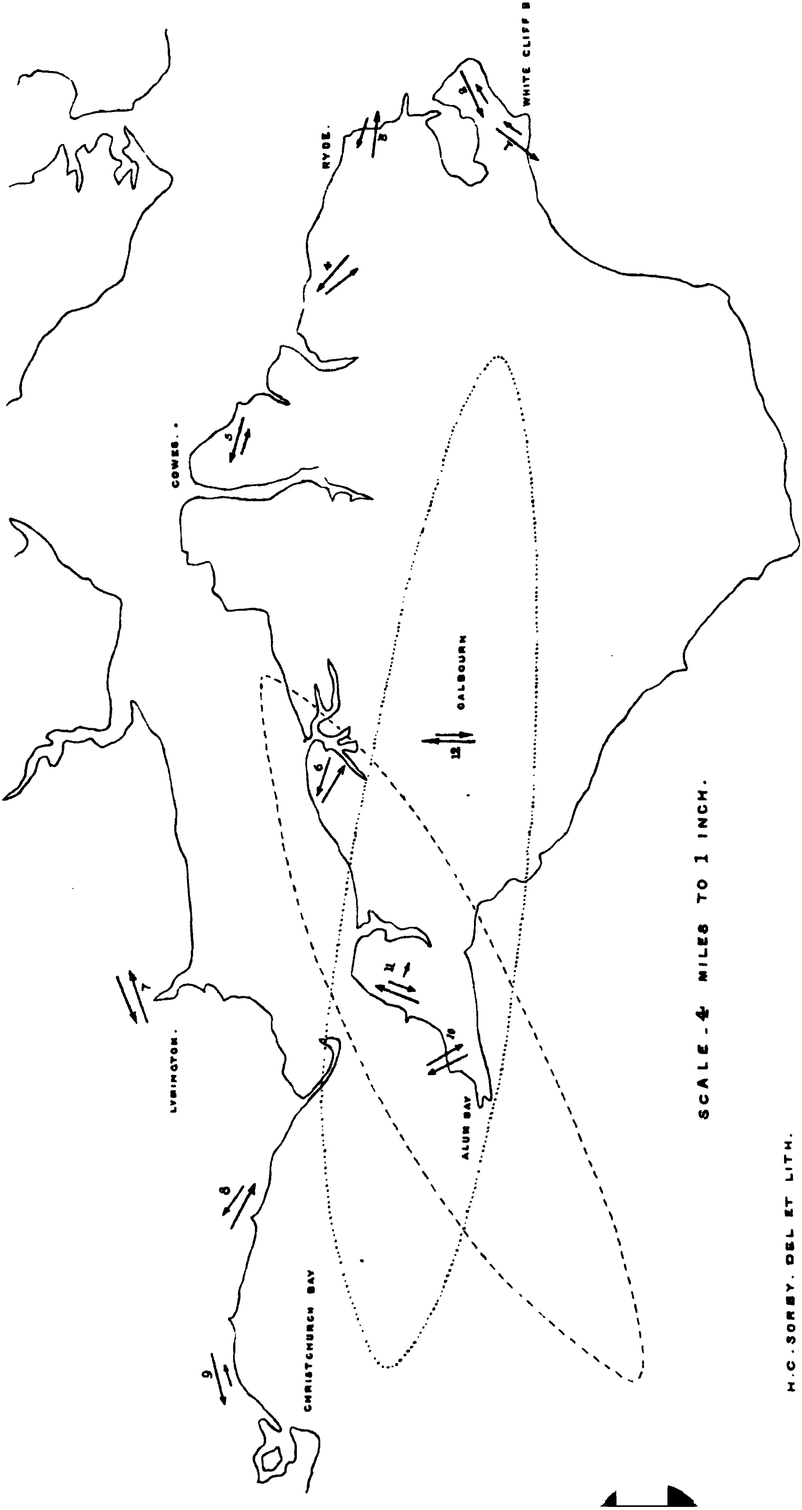
* New Series, vol. iii. Jan. 1856, p. 112, and vol. iv. Oct. 1856, p. 317.

Waves caused by the action of the wind on the surface of water produce, as they pass onward, a current moving in the line of their advance under their crest, and in the opposite, in the intermediate hollow. The extent of this motion, and its velocity, depend on the height and length of the waves, and the depth of the water. If this be considerable, compared with the dimensions of the waves, there is no motion of any importance at the bottom; but if they advance to where it is shallow, as, for instance, to a coast or a shoal, the movement along the bottom becomes considerable. It is then an oscillating current, moving forwards and backwards in the line of their advance, and perpendicular to their ridges, as extending on the surface of the water. Even if the line of motion of a system of waves be parallel to the shore at some distance from it in deep water, yet, when approaching a shelving coast or shoal, their ridges curve to it in such a manner that, when the depth becomes such that the velocity of the currents they produce at the bottom is sufficient to move the deposits, the direction of the line of oscillation is inclined at a considerable angle to that of the coast. Hence, if the same effective amount of waves comes from all quarters, the mean direction of this line would be perpendicular to the shore, and the range of variation would be about a right angle; whereas, if that was not the case, this mean line would be inclined from the perpendicular towards the side from which the greatest amount of waves proceeded. As before mentioned, the direction of tidal oscillation, some short way from the coast or shoal, would be parallel to it, and hence, that due to the stranding waves

PLATE IV.



SCALE. 4 MILES TO 1 INCH.

H. C. SORBY. DEL ET LITH.

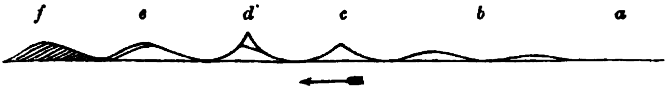
would be nearly perpendicular to that of the rise and fall of the tide. This fact enables us to ascertain the existence and form of the coasts and shoals in the ancient seas, in the same manner as breaking waves serve to point them out to the navigator of those of the present period.

These conclusions are derived from the general and well-known phenomena of wave motion,* and from my own observations at various places on our coasts, which may be so easily made, that any one may readily repeat them, and convince himself of their truth.

When deposits are formed under the influence of a current, the character of the resulting structure depends on its velocity and depth, on the nature of the deposit, and the rate of deposition, which are so connected together that, I feel persuaded, on more extended inquiry, it will be found possible to ascertain their approximate value by examining the rocks. So much, however, remains to be learned by experiments, that I shall not now attempt to do more than indicate in what way the direction and character of the current can be determined, because that is all that is required for the subject in hand.

The direction of ripple-marks clearly shows that of the current which produced them; for they trend perpendicular to its movement, in the same manner as the waves of the surface of water do with respect to the wind. The current often washes forward material, which is deposited in small beds on that slope of the ripple opposite to that from which it flows. This will be better understood from fig. 1, which is an ideal section perpendicular to the trending of a system of ripples, to show the gradual passage from "level beds" at *a* to gentle curved "ripples" at *b*, becoming crested at *c*, and so sharp at *d*, that the upper part would be washed off to where there is a dotted line, carried forward in the line of the current, and

Fig. 1.



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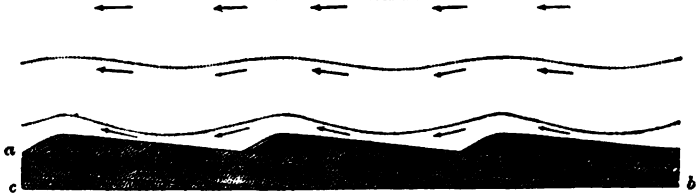
* See Airy's Treatise on Tides and Waves, in the Encyclopædia Metropolitana, and Scott Russell's Report on Waves, in the Report of the British Association for 1844, p. 311.

thrown down as a small bed at (*e*), on the side towards which the current flows. Fresh material being washed up from the exposed side of the ripple, carried forwards and deposited on the protected side, such a structure as at (*f*) is produced, which I call "ripple-drift." If no permanent deposit was being formed, merely matter drifted onwards, no more material would be added to the protected than would be afterwards washed up from the exposed side; therefore systems of such ripple-drifts would simply advance, and leave nothing behind them. If, however, an actual deposit was being formed, so that more material was added to each ripple than was afterwards washed up again, the lower portion of each would be left behind, and covered up by the next advancing over it. Provided that the accumulation took place at a uniform rate, thin beds, like those shown in fig. 2, would be left behind, having stratula,* as shown in the figure; whereas, if there was a fluctuation in the rate of deposition, the thickness of these bands would vary accordingly. By this means, then, there are produced bands of oblique-bedded stratula, each of which does not coincide with the true horizontal plane of stratification, but is inclined to it at an angle, *abc*. Since the thickness of each of these bands is necessarily the amount of material accumulated during the interval required for each ripple to advance through a space equal to its own length, it is obvious that, when the laws of the rate of this advance have been accurately ascertained, the rate at which the deposit was accumulated will also be known. Of course, if the surface of the ripples can be seen in any rock, the direction of the current can be ascertained at once; but, as is often the

Fig. 2.



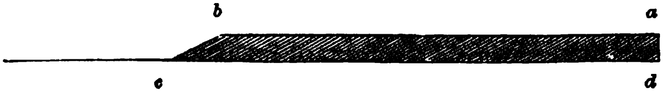
* I most willingly adopt this term, first proposed by De la Condamine in his paper in the Quart. Journ. Geol. Soc., vol. ix. p. 273.

case, if it cannot, this may be learned by taking the mean dip of their stratula, which, owing to the tendency to form small delta-like accumulations, frequently varies considerably. I have now before me in my cabinet specimens showing most perfectly all these peculiarities of structure, as well as most of the others described in this paper.

In some cases, when the current is not of such a character as to produce ripples, and yet is strong enough to drift material along the bottom, there is produced on the surface of the beds a peculiar banding and graining in the line of its movement. This is seen to so great perfection in some thin-bedded flags, as to show the direction of the current in a most satisfactory manner; but it is not easily recognised in such rocks as those in the district under consideration.

The direction of the current can also be most satisfactorily ascertained from that peculiarity of stratification which has usually been called "false-bedding." A single bed of this is shown in fig. 3.

Fig. 3.



Since this kind of structure is due to material being *drifted* along on the bottom, where the velocity of the current is sufficient to move it forwards, until it arrives at a place where the depth becomes so much more that this velocity is so reduced that it can move it no farther, I have proposed for it the term *drift*-bedding, in contradistinction to true horizontal stratification, formed by simple deposition without such drifting, and to ripple-drifting, where the structure has been modified by the formation of ripples. I object to the term *false*-bedding; because it would be quite as applicable to the bands of ripple-drift (and in such cases it is not *false*), and would restrict it to certain cases of unconformable junction of the layers of beds, neither due to true drift-bedding or ripple-drifting, but which may be truly said to have *false stratification.* These various structures are entirely distinct, and should most certainly be known by different names. Though drift-bedding is usually in larger beds—I have seen some upwards of 25 feet thick; yet in many cases their size is no greater than that of bands of ripple-drift; but then they are essentially distinguished by the facts, that each bed of drift-bedding is parallel to the true plane of stratification, is independent of any other, and may exist alone, as fig. 3; whereas, in ripple-drift, each is inclined to it at an angle, as *a b c*, fig. 2, and can only occur grouped with others. The well known ripple-marks are those particular cases of ripple-drift where circumstances have so occurred that the rippled surfaces are preserved. In very many rocks this is an exception; and they have only so influenced the structure as to give rise to what would commonly be called small false-bedding, or oblique lamination. My *ripple-drift*, therefore, includes most cases of *ripple-marks*, and much more besides; in fact, all structures due to their action, whether their perfect *upper surfaces* are preserved or no.

In order to illustrate the production of drift-bedding, I have constructed a working model, which I exhibited and described at the late meeting of the British Association at Cheltenham. In it the action of the current is represented by a kind of coarse screw, which carries forward from a receptacle a mixture of fine, black, specular iron-sand or emery, with about four times its bulk of coarser white quartz sand, as if it was drifted along the bottom of water by a current; for instance, from *a* to *b* of fig. 3. Arriving at the point when it can escape from the action of the screw, like when the current can carry it no farther, as at *b*, it is thrown down on a slope, at the angle of rest, as at *b*, *c*. By turning the screw alternately, quickly and slowly, the heavy fine black and light coarser white sand become sorted, and form distinct stratula, visible through the glass front, just such as are produced by fluctuations in the velocity of the current; whereas, if it is turned round at a uniform rate, no such distinct thin stratula are formed; the only sorting being the accumulation of the fine particles at the top, and the coarser at the bottom, precisely as is invariably found to be the case in natural drift bedding. When due allowance is made for the smaller value of the angle *b c d*, produced by subsequent changes that have sometimes taken place in the material, so as to cause it to occupy less space, or for its original smaller size, that occurs where drift-bedding is tending to pass into the horizontal-grained structure already alluded to, it is found, not only that the general appearances thus artificially generated are precisely like those found in the natural rocks, but all the minute details so entirely correspond, that the manner in which drift-bedding has been produced can admit of no doubt whatever, nor that we may confidently rely on it for determining the direction of the currents, as will, I am sure, be admitted by all who have seen the model in action. Such are now made by, and may be procured of, Messrs Chadburn Brothers, opticians, Sheffield.

As will at once appear from what I have said, the direction from which the current came is opposite to that to which the stratula dip, allowance of course being made for any disturbances that may have subsequently occurred. This, as well as that of the ripple-drift, is often easily determined and measured in ancient deposits, and thus the exact point from which the current came is known. Modern cases would lead us to expect that there would be considerable variation in different parts of a bed in the same locality, though formed under the same general conditions. This is what is found to occur in older rocks; but then, by ascertaining the directions in various parts, and taking their mean, the average is known, which is the fact required. For these structures, due to the action of currents, I propose the general term, "current-structures;" and have adopted the following symbols to represent them, which are of very great use in describing the characters of rocks. I have chosen them from such types in common use as do actually somewhat resemble each particular kind, so as to be more easily remembered.

For "level-bedded," (a dash)	—
For "ripple-drifted," (a section) . . .	∽
For "drift-bedded," (symbol for angle) . .	∠

By using these symbols the character of a bed of rock is easily expressed, by writing them in the order in which the amount of each kind of structure exists in it.

All these various current structures may often be most conveniently studied in progress in clear rivers; and in wet weather in the streams running by the side of country roads, that are mended with sandy material; and when these are dried up, the most instructive examples of all of them may be observed, and their intimate structure ascertained, by cutting into them. In those actually in progress, the relation between the configuration of the channel, the current, and the structures produced by it, may be readily seen; and, when dried up, we may see that the current-structures clearly show the direction of the previous current, and that, if the confining banks were to be removed, they would also indicate their general direction in the most satisfactory manner. We may likewise readily observe the fact, that when sand is thus drifted along, in cases where we can see it, one or other of the structures is invariably produced; and that thus, by one or other, according to the circumstances of the case, the direction of the current could be ascertained; and when we cannot inspect it, it is only reasonable to conclude that the same causes produce the like effects. Now, in ancient deposits, we have clear proof that the material of which they are composed must have been transported by some current; and when we examine the rock, we find these structures in all their detail; and hence I think the conclusion necessarily follows, that from them its direction can be satisfactorily determined. I need scarcely remark, that the facts I have so far referred to occur where material is drifted along the bottom, and not where fine mud is first held in suspension in water, and then subsides through it by mere gravitation. The rate at which this takes place would prevent any but very fine grains being transported far by that means by water of no great depth. Many of the strata in the district under consideration appear to have been thus formed, when the currents were not such as could drift forwards the coarser particles of sand; but the coarser grained have the current-structures, as if accumulated by the drifting of material along the bottom, and it is to these, as showing the directions of the currents, that my remarks will be confined in this paper.

If the current be simple, and move only in one direction, though there may be a considerable range of variation, yet the current-structures will show that it was only from one side; whereas, if it be oscillating, as due to the rise and fall of the tide, or to the action of stranding waves, it will be found that they indicate a movement forwards and backwards along a particular mean line. The character of the structure in this case will be seen from fig. 4—

Fig. 4.

From Magnesian Limestone near Tickhill. Scale $\frac{1}{10}$ nat. size.

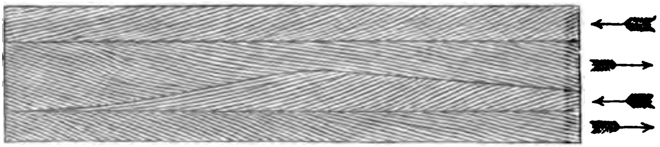
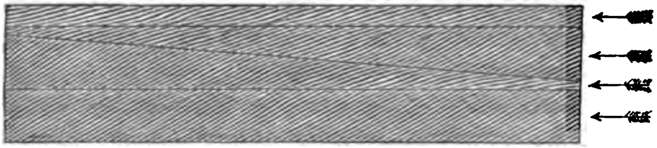


Fig. 5.



where the arrows show from which side the current came for each bed; but if there had not been any such oscillation of the current, the stratula would have dipped to one side in every part, in the manner shown in fig. 5. The same facts are also seen with respect to ripple-drift; there being in one case bands of such a structure as to indicate a simple current from one side, like fig. 2, and in the other alternations of those, showing it to have been first from one side and then from the opposite. By examining what occurs in simple currents, like those of rivers, it is easy to see that the material is deposited only on one side of the ripples; whereas, in oscillating, like those of waves, it is seen to be deposited first on one side and then on the other, and thus gives rise to ripples of a peculiar kind, having portions with stratula dipping in opposite directions, as may be seen by cutting into such on a beach, and as are so often met with in older deposits; and I think there cannot be the slightest doubt that the same must occur when cirumstances are such that drift-bedding, like fig. 4, is produced by oscillating currents. It does not, indeed, necessarily follow, or is it at all likely, that each set of opposite stratula was due to a single wave or tide; but the most probable conclusion is, that each bed was produced during a much longer interval, when the oscillating currents caused a preponderance of action in one or other direction, in accordance with what I describe farther on, when treating on temporary deposition. That drift-bedding or ripple-drifting, with the stratula in different parts dipping alternately in opposite directions, does really prove that the currents were *oscillating*, in my opinion admits of no doubt, and cannot be explained in any other manner, on strict experimental and general mechanical principles. On the contrary, such a structure as that shown in fig. 5 indicates as conclusively that none but simple currents, moving only in one direction, were instrumental in producing it, though, of course, it is possible that occasionally some, too gentle to move the deposits, might flow in an opposite direction. It may be well here to remark, that the delta-like form in which drift-bedding and ripple-drifting are often accumulated, may cause an apparent indication of oscillation where such is not really the case, if the section be cut in particular directions, and care be not used in examining them; in the same manner as we might be led to conclude that a rock dips in a very different direction to what it actually does.

The Magnesian Limestone, in the south of Yorkshire, has furnished me with a most excellent example of oscillating currents. Those due to the tide are extremely regular over a space of twenty-five miles in a direction across the currents which I have explored very thoroughly; and in no place out of several hundred localities are there any simple currents without oscillation. The upper bed of the Millstone Grit in South Yorkshire and North Derbyshire is, on the contrary, a good illustration of a simple current very uniform over a similar space, without any merely simple oscillation, as if it had been such a wind-drift current as is described in my paper on the Physical Geography of the Old Red Sandstone Sea of the Central District of Scotland.* Indeed, the carboniferous and Permian rocks of this district afford most excellent opportunities for this study; and when, in roaming over my native hills, I see such thousands of most excellent examples of all the structures I have described, both in the act of being formed in the modern streams and rivers, and as existing in the older rocks, I am utterly amazed that scarcely any one but myself should have entered on this field of inquiry, and can only account for it by supposing that geologists have generally been too intent in studying the organic remains to pay attention to the no less important physical structures of the rocks. That these will, however, on careful examination, yield very valuable and instructive facts is my most firm belief.

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* Edinburgh Philosophical Journal, vol. iii., p. 112, Jan. 1856.

It is best to ascertain the direction and relative amount from each side in oscillating currents; because the facts of not being equal or opposite are of much importance in deciding several points of great interest. In order to represent the oscillation of currents, I use the mathematical symbol for "varies as," viz., $\propto$, which appears to me extremely well suited for the purpose. If, then, there was oscillation from north to south, and south to north, I express it thus—N. $\propto$ S.; which is to be read, "north oscillating with south." If the number of observations from each side be written, their relative amounts are also seen. For instance, if the oscillation was from N. 20° W. to S. 30° E., with 20 observations from one, and 10 from the other, I represent it thus—N. 20° W., 20 obs. $\propto$ S. 30° E., 10 obs.

I trust that I have now explained these general principles sufficiently for the purpose more immediately before us. My main argument may be summed up as follows:—The examination of modern seas, estuaries, and rivers, shows that there is a distinct relation between their physical geography and the currents present in them; currents so impress themselves on the deposits formed under their influence that their characters can be ascertained from those formed in the ancient periods: therefore their physical geography can be inferred within certain limits.

It is most important that a clear distinction should be made between the *temporary deposition* and the *permanent accumulation* of deposits. If the bottom of the water on a sandy coast on which waves are breaking be examined, where the depth is such that it may be seen through the clear water, and the waves act on the deposits, the sand may be seen to be carried over the ripples towards the shore as the crest of each wave passes, and back from it as each hollow moves over it. In this manner the sand is, for the short time, often deposited with considerable velocity, but is only moved backwards and forwards. If the sea be not rough, the peculiar properties of low long waves advancing to shallow water cause the sand to be drifted more to than from the coast; and hence, for the time, there is a temporary accumulation. If, however, there be a rough sea, with large, high waves, capable of moving the deposits at a greater depth, and more equal in their action to and from the coast, the material thus accumulated is carried farther out from it, to be again brought in during another calm period. In both these cases there cannot, I think, be any doubt that the ultimate structure of the sand would show the action of an oscillating current, and would also indicate, in many cases, a rapid deposition; and yet there might be no permanent addition to the material, and no permanent accumulation during an indefinitely long period. But if a change in depth, by subsidence, or some other alteration in physical geography, should occur, so that material might be deposited quite out of the influence of the subsequent action of the currents, there might be a permanent accumulation of strata; and since such would, in all probability, have been formed during some extraordinary storm, when the waves acted at an unusual depth, their structure might indicate a *rapid deposition,* whilst there might have been a *very slow permanent accumulation,* which would perhaps include an indefinitely long period, where no such permanent accumulation took place. Though we cannot readily examine what goes on in deep water out of the influence of surface waves, yet it appears to me only reasonable to conclude that the same kind of facts occur with respect to tidal-currents, whose velocity has been ascertained by observation to be often such as would produce the various current structures. Indeed, it is well known, and is frequently mentioned in "sailing directions," that the chief changes in the form and position of shoals, and the depth of the water, are due to extraordinary high tides, produced during storms by the combined action of the wind and ordinary tide. We may therefore, I think, conclude, that when any permanent accumulation takes place, it will often indicate an unusual rate of deposition of material, which it may have taken ages to accumulate in some situation from which it was removed, and permanently fixed in another locality during some storm. When thus, however, permanently preserved from subsequent changes, I think it is only legitimate induction to suppose that its ultimate structure would indicate the direction and nature of the currents present during its deposition, whether they be simple or oscillating, or of such characters as to give rise to one or other of the current structures already described, according to the circumstances of the case.

In inquiries like the present, it is necessary to take into account the unequal amount of winds from different quarters of the compass. In this part of the world the resultant mean is nearly W.S.W., and the violent gales are far more common from the west side of north and south than from the east.* The size of waves produced by the action of the wind, as is well known, depends on its strength, and on the time and distance that it has acted on the water. If, then, a place in a sea be so situated that the distance to the coast on the east was equal to that to the west, the stronger and more general west winds would cause the largest and most prevalent waves in that locality to be those due to the western winds, which, of course, would move in the same direction. But if the distance to the east coast was very much greater than to the west, the less violent eastern winds, blowing over a greater expanse of water, would give rise to larger and more effective waves than the stronger western, acting over a less space. These facts may easily be observed by any one on the eastern coast of England, and are constantly taken into account by mariners;

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* See Sir W. Snow Harris' Report on the observations of the winds at Devonport and Greenwich in the British Association Report for 1844, p. 241; Maury's Physical Geography of the Sea, and his Wind and Tide Charts; and Johnston's Physical Atlas, first edition, Meteorology, Map No. 2.

and they are of great importance in the subject under consideration.

As before remarked, the organic remains in the upper Tertiaries of the Isle of Wight, clearly indicate that they were deposited in an estuary at the mouth of a great river. In such a case, judging from what occurs now, we should expect to find shoals with deeper tidal channels between them; for instance, like those shown by a chart of the mouth of the Thames. The action of the tide causes such shoals to be elongated in the line of the axis, and to run more or less closely in the directions of the currents. In studying, then, an ancient estuary, the chief points to be determined are,—what was the line of its axis, which way it opened into the sea, and the position of the shoals. In this communication I shall confine myself almost entirely to the application of the physical principles I have described, and must refer to well-known publications for the general geological structure. On the accompanying map (Plate IV.), the directions of the currents in the various localities are shown by the arrows, and the relative amount from each side by their length. An inspection of it, I think, at once shows that the axis of the estuary in this locality ran from near W. by N. to E. by S., and that there was a considerable shoal in the part included in the dotted line; as proved by the currents there being perpendicular to the axis, in accordance with the principles already described. This, I think, completely explains why the sections at Alum Bay and Whitecliff Bay differ so much from one another; for one is through a shoal, and the other through deposits formed in a deeper tidal channel.

It will now, perhaps, be best to describe some of the facts at each part, and to give the actual means, which are represented on the map by arrows. All the bearings are to true north. Commencing in Whitecliff Bay, and referring to the admirable sections of Prestwich (Quarterly Journal of Geological Society, vol. ii., Plate ix)., I was unable to detect any evidence of currents in the lowest part till coming to the upper portion of the "Bognor Beds." Passing upwards, there are alternations of beds showing current structures with others that do not. However, the verticality of the strata renders it impossible to ascertain their direction with great accuracy; but, so far as I could determine, they were, in the marine beds, on an average, N. 37° E., ∝ S. 37° W., in some cases more from N.E., and in others S.W., but on the whole more from N.E. These are shown on the map by the arrows numbered (1); and the others, described below, will be numbered to correspond in the same manner.

(2.) When we come to the horizontal and more fluviatile beds, the directions can be ascertained with sufficient accuracy. They were N. 64° E., 47 obs., ∝ S. 60° W., 13 obs., being the means of the means for the various beds, which do not vary much. These results do not differ materially from those in the lower beds; so that I think we are warranted to conclude that the general line of oscillation was so similar for the whole period as to prove that no coast or shoal was formed.

(3.) In the limestone, on the coast north of St Helen's, we have N. 83° W., 15 obs., ∝ S. 72° E., 11 obs.; whilst in a small bed of sandstone I found indications of a shoal, but not sufficient to determine the directions with accuracy.

(4.) In the quarries at Binsted, S. 50° E., 15 obs., ∝ N. 42° W., 15 obs. The tidal action here was much the most strongly marked in the lower, more quartzose, sandy portion.

(5.) East of Cowes, S. 74° E., 7 obs., ∝ N. 72° W., 4 obs.

(6.) Hampstead Hill, S. 73° E., 3 obs., ∝ N. 60° W., 3 obs.; but the currents here were generally very feeble, and there is seldom evidence of any.

(7.) Near Lymington, S. 70° W., 15 obs., ∝ N. 73° E., 14 obs.

(8.) In the beds above the Barton Clay, near Hordle, N. 63° W., 36 obs., ∝ S. 56° E., 29 obs., being the means of the means of the various beds, which do not differ much from each other.

(9.) I could not make out any current structures in the Barton Clay, but below it, near Muddiford, N. 76° E., 13 obs., ∝ S. 74° W., 5 obs.

These various means, as will be seen from the map, do not differ from one general direction more than would be likely to occur from the interference of shoals and other causes; and, of course, allowance must be made for slight errors of observation; because it is not always possible to see so many good cases of current structures, as to give a perfectly correct mean. I think it cannot be doubted that the whole of those I have given are axial oscillations. The means of the means of those in the fluvio-marine deposits, viz.—Nos. 2, 3, 4, 5, 6, 7 and 8, are S. 77° E., 126 obs., ∝ N. 78° W., 101 obs. These may be relied on as sufficiently exact; but the direction of the currents at the period of the lower, more purely marine, deposits can be determined in so few instances, and then not in a satisfactory manner, so that it cannot be known nearly so well as could be wished. However, so far as I could ascertain, it was N. 68° E., ∝ S. 56° W.; certainly most from the former. This, then, is not exactly parallel to the other, but intersects it at an angle of 40°; being more to the S.W. than the other. Although I cannot rely on it fully, yet, since the same facts are indicated at each locality, and there are several other reasons that tend to confirm it, I think it will be best to conclude, provisionally, that the line of axis of the marines was not exactly the same as that of the fluvio-marines.

In the "mottled clays" in Alum Bay, as was the case at Whitecliff Bay, I could find no current-structures; nor till coming to the centre of the "Bognor Beds." There I saw evidence of a current from near east, which would agree well enough with the general axial direction. Passing upwards to the "lower division of the London Clay" of Prestwich's section, in the beautiful striped sands and clays, it is difficult to tell the directions accurately on account of the verticality of the strata; but I concluded that they were somewhere about S. 18° E., ∝ N. 18° W., in nearly equal proportions. In the more horizontal "Headon Hill Sands" the directions can be ascertained with sufficient accuracy, and I there found them to be S. 28° E., 13 obs., ∝ N. 32° W., 12 obs. (No. 10 of the map), or closely the same as in the beds below. These directions are inclined at 89° to the line of the axis for the marines, as given above, or almost exactly perpendicular. This, then, appears clearly to indicate, in accordance with the principles already described, that the currents were those due to wind-waves stranding on a shoal or coast. I therefore conclude that there was a shoal here, running in the line of the axis, as shown by the broken line on the map.

(11.) The means of the means in the various beds of the fluvio-marines of Headon Hill to Sconce Point, are S. 22° W., 65 obs., ∝ N. 18° E., 41 obs.

(12.) In the limestone near Calbourne, S. 2° W. 25 obs., and N. 2° E., 14 obs.

These, it will be seen, are nearly perpendicular to the axial line. The means of both, (viz., of 11 and 12) are S. 12° W., 90 obs., ∝ N. 10° E., 55 obs., which are inclined at 89° to the axial line of the fluvio-marines, or almost exactly perpendicular. This would agree with the supposition that there was still a shoal, but that its direction was not exactly the same as at the period of the marines, but had changed to that of the fluvio-marine axis, as shown by the dotted line on the map. If such was the case, and when there were no high winds to produce waves of material size, if there was a general axial current due to a river, we might expect to find indications of it, even on part of the shoal. Such, indeed, is the fact; for I found cases where there were beds or stray bands showing such a current, and giving a mean of N. 70° W., from 10 obs., or within 10° of the axis, which is as near as could be expected from the nature of the case. This is shown by the small arrow at (11) of the map.

It appears to me, therefore, that, in the part now constituting the western end of the Isle of Wight there was either a coast or shoal. So far as the directions of oscillation are concerned, either supposition would agree with the facts; but there are reasons for supposing it was a shoal. Unfortunately, there now remain no Tertiary deposits on its south side, so that this could be decided by an examination round it (in the manner I have been able to do in the case of the Magnesian Limestone in South Yorkshire); but it appears to be a decided fact, that on the whole there was very considerably more material carried from the south than from the north, as though the effects of the oscillating currents had been greater from the south side. This would agree perfectly with what would occur if the waves came from the south; because mathematical investigations,* and my own observations, show that there is a considerably greater effective force in the line of a wave's movement under its crest, than backwards below the depression. Besides this, if the line of the shoal at the period of the lower marines was as I have given above, the deposits at Whitecliff Bay and Barton would be on opposite sides of it, and hence there could scarcely have been a genuine coast-line. It is these considerations that lead me to infer that it was a shoal, cast up by the action of waves, proceeding chiefly from the south; and, since the currents in the lowest part of the marines are axial, it should appear that the period of its first production was during the "lower division of the London Clay" of Prestwick's section, or just where the difference between the strata here and at Whitecliff Bay becomes so remarkably apparent, and it continues upwards to the upper part of that division. In the "upper division of the London Clay" I could find no indication of a current, and the inference I draw is, that the depth was then too great for the waves to move the deposits at the bottom; but when we come to the "Headon Hill Sands," it was so diminished that the same shoal-action is again met with.

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* See Professor Stokes' paper in Cam. Phil. Trans., vol. viii. p. 446.

As stated above, the probable line of the axis for the rise and fall of the tide in the lower marines is from E.N.E. to W.S.W. The number of observations, and the extent of the district I have examined, are not sufficient to enable me to pronounce for certain; but the facts, so far as they go, distinctly point to the conclusion, that the sea communicated with the main ocean of the period on the east side; for this would account for the excess of force being from that. Besides this, if it had opened to the west, the great excess of storm surface-waves from that side, produced by the prevailing W.S.W. winds, would have caused the line of shoal oscillation to have inclined considerably towards it; whereas the evidence is that, if anything, the contrary was the fact. These suppositions would agree very well with the great extension of the deposits of this period over central and southern Europe, right into Asia.

Now, I think one cannot fail to be struck with the remarkable parallelism between this line of tidal oscillation and that of the elevation of the older rocks from Bath to Cambridge, which is almost exactly parallel to it; as though the coast to the north-west that determined the line of movement of the tide was related to that direction of elevation. It also distinctly points to the fact of the Wealden elevation not having then occurred, in accordance with what is proved by other phenomena. In the same manner, the line of axis of the fluvio-marines is very similar to that of those repeated movements that have effected the south coast of England, running from a little north of west to south of east, viz.:—

	Trending.
In Devonshire, after the Carboniferous, and before the Permian period, . .	S. 80° E.
In Dorsetshire, after the Oolitic, and before the Cretaceous period, . . .	S. 85° E.
In the Isle of Wight and Wealden district, after the Tertiary period, . .	E. to S. 80° E.
Axis of the fluvio-marine Tertiaries, as deduced above, after the Chalk, but before the conclusion of the lower Tertiary period,	S. 78° E.

It should therefore appear, that after the formation of the lower marine Tertiaries a gradual movement took place, in a direction similar to what has thus repeatedly occurred in this part of England, so as to cut off the sea to the south, give rise to a new line of axis, and determine the existence of the estuary of the fluvio-marines by the crossing of the two lines of elevation named above, in precisely the same manner as that of the Thames of the present period was produced by the intersection of the first named line of elevation with that of the Wealden district. That this elevation and change of line of axis during the lower Tertiary period were gradual, is, I think, indicated by the absence of any decided break in the strata, and by the fact that the beds intermediate between the two portions give an intermediate line of oscillation. I think the evidence leads to the conclusion, that the shore thus produced was considerably south of the Isle of Wight; but perhaps some change occurred also north of it; and indeed, though the facts do not prove it, yet they in many respects render it probable that the line of elevation of the Wealden was partially developed at the same time. (See figs. 6 and 7.)

These conclusions would agree with the supposition that the river came from the west, and of this I think there is good physical proof. In the more purely fluviatile deposits at the western part of the Isle of Wight and in Hampshire, the amount of action from the west side is to that from the east, on an average as 3:2; and the axial currents over the shoal in the Isle of Wight are, so far as I saw, all from the west, as if the river came from that side. Moreover, the fact of the surface-wave oscillations on the shoal being so nearly perpendicular to the axial tidal currents, could not, I think, be accounted for more satisfactorily than by supposing that there was land to the south and west to protect the water, so that the more violent gales from that side should blow over such a smaller surface of sea, that the waves in the district under consideration should not be so great as those produced by the less violent easterly winds blowing over a larger expanse of water. On the whole, then, I think, it may be concluded that the river came from the west; and though I have wished to throw the purely physical data into the front of the battle, does not the distribution of the organic remains agree equally well with this supposition?

It will now, perhaps, be well to consider some of the facts connected with the actions present during the period of the fluvio-marines. Though I have shown that the oscillation of the currents very strongly indicates tidal action, yet it must not be thought that it was present all along in any considerable amount. In fact, the evidence is, that in many cases it was nearly, if not entirely, absent; for very often the strata furnish no indication of any current of importance. It is an extremely common fact to find at the mouth of a large tidal river more or less of a bar, formed by the interfering action of the river and tide. This would, of course, to a certain extent, keep out the sea-water, and impede the tidal action in ordinary cases, so that the water above it might generally be more or less fresh, and not subject to currents of material velocity. However, in unusual storms from seawards, an extraordinary rise of tide might occur, and produce such currents as would wash up deposits formed under more fluviatile conditions, and generate current structures related to the axial line. We might also expect that, in the progress of changes occurring over a long period, the configuration of the estuary would vary in such a manner as to cause the extent of tidal action to differ very materially. The physical structure of the fluvio-marine deposits under consideration agrees very well with these suppositions, and so, I think, do the characters and distribution of the organic remains.

If I am right in inferring that there was a shoal as described above, and not a coast line, in the western part of the Isle of Wight, it is difficult, if not impossible, to ascertain the dimensions of the estuary, because its southern boundary has been removed. Nevertheless, to explain why the shoal was thrown up by waves from the south, I think we must conclude that the south coast-line was as far, or farther, from it than the north, and, if so, the breadth of the estuary must have been at least 15 or 20 miles, or somewhere about the size of that of the Thames east of the Isle of Sheppy. Notwithstanding this, it would appear that the dimensions of the river were such as to keep the water in general more or less fresh; and though there are difficulties in the way of forming an accurate conclusion, yet I think we cannot but infer that to do this a river much larger than any now running in Britain would be required. I have already shown that there is evidence that land existed to the south, west, and north; and if a great river came from the west, I think the inference is, that it was of considerable extent, and that its drainage ran into the sea through the tertiary estuary of the Isle of Wight.

These general conclusions will be better understood from the accompanying figures, which are only intended as diagrams to illustrate the general conditions, and are not professed to be more than first approximations, for reasons already given.

Fig. 6.

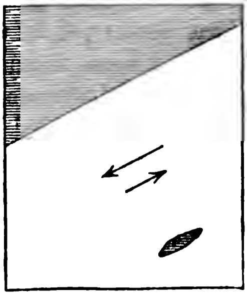

Fig. 6 shows the direction of the rise and fall of the tide at the first period, before the estuary was formed, the line of coast that would give rise to that direction, and the Alum Bay shoal.

Fig. 7.

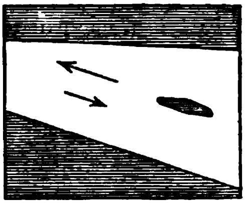

Fig. 7 shows the direction of the estuary at the period of the fluvio-marine strata, with the line of the rise and fall of the tide, and the shoal in its altered position. The change from the first to the latter condition was not sudden, as is proved by the directions of the currents in the intermediate beds being intermediate, as described above; but yet it does not necessarily follow that it was uniformly slow and gradual. These facts, and the verticality of the strata in Alum and Whitecliff Bays, render it difficult to ascertain the exact period of the change. In the vicinity of Barton it appears to have occurred, so that the second line of axis was fully established when the strata just above the Barton Clay were deposited; whereas in Alum Bay this was not the case until the period of the upper portion of the Headon Hill marls and limestones; as though, like the passage from marine to freshwater conditions, the change had progressed from the west towards the east. When completely formed, the general mean line of the axis of the estuary does not appear to have varied much; though its configuration may nevertheless have changed very materially; its depth, and the position of its bounding coasts, may have undergone great alterations. Indeed, the alternation of beds of different physical character, independent of what is learned from the study of the organic remains, in my opinion clearly indicates that such changes did occur; but these might have been very considerable, and yet the mean line of axis might have remained nearly the same. For instance, in the case of the present estuary of the Thames, if, by subsidence or other changes, it was to be extended, so as to comprise the whole of the London Tertiary basin up to the range of the Chalk, so as to cover the whole of the triangle included between Norwich, Hungerford, and Canterbury, we should have a very great change in geography; so much so as to produce a total alteration in the nature of the materials accumulated in many parts of the present estuary: and yet the *mean line of axis* would not be materially different from what it is now. In the case of that in the Isle of Wight, now under consideration, it appears to me to be a question of examination of facts to decide whether this was so or not. The best evidence in this respect that I know is that derived from a comparison of the directions of the currents, as observed in the various strata seen in the section along the coast from Barton to Milford. Dividing the means into three groups, for the lower, middle, and upper beds, we have for the lower, N. 68° W., 16 obs., ∝ S. 69° E., 15 obs.; middle, N. 68° W., 15 obs., ∝ S. 51° E., 10 obs.; upper, N. 69° W., 13 obs., ∝ S. 66° E., 11 obs.; which agree so closely as to show that no material change in the line of the axis had occurred. There is also a similar agreement in the section at Whitecliff, and in the highest beds at Hampstead Hill; though the current was so gentle that its direction cannot be determined well there.

It appears to be very probable, that over the shoal already described the depth could not have been above a very few fathoms, and it might even in part have sometimes constituted dry land; which would account for the greater abundance of land shells in the limestone of the western part of the Isle of Wight. A most careful examination of the distribution of the organic remains, in connection with the physical structure, would indeed be very instructive, but would require much time and attention. I have confined myself as much as possible to purely physical data; but at the same time I think that the facts deduced from them will agree with many of the leading conclusions with respect to the distribution of the various organic remains. For instance, the deeper marine character of the lowest beds; the absence of shells in the "lower division of the London Clay" of Prestwick's section at Alum Bay, and their presence at the same horizon in Whitecliff Bay; and the more marine character of the fossils in beds at Whitecliff, which are equivalent to those that are almost, or entirely fluviatile north of Alum Bay. However, I must leave the detail of this part of the subject to those who are far more capable than myself of doing it justice.

As illustrating some facts of importance in connection with the Tertiary deposits, perhaps it would be well to mention some of the phenomena I have observed in the Drift-Sand and gravel in Hampshire, from Lymington to Christchurch. The line of tidal oscillation was S. 80° W., 49 obs., ∝ N. 86° E., 24 obs. In accordance, then, with the principles already described, this would lead us to infer that the line of coast that directed the currents ran nearly east and west, and that the tide came from the west side. There is no difficulty in seeing that this was really the fact; for the direction of the chalk hills to the south in the Isle of Wight is within 5° or 10° of being parallel to it, the difference agreeing with what would be produced by action of the line of the chalk to the north; and we may consider it almost certain that the tide came from the west side. This close agreement between the general physical geography indicated by the current structures, and that which other facts prove must have been the case, tends, I think, to inspire us with considerable confidence in applying the same general principles to determine that of earlier periods.

On Hydractinia Echinata. By T. STRETHILL WRIGHT, M.D., Fellow of the Royal College of Physicians, Edinburgh. *

Explanation of Plates.

PLATE V.

Fig. 1. Diagram showing the various polypoid forms observed on the (female) polypary—*a*, spiral polyp—*b*, reproductive polyp—*c*, alimentary polyp—*d*, sessile ovary—*e*, tentacular polyp.

2. Solid grooved papilla of corallum.
3. Hollow papilla of corallum.
4. Ideal section of the extremity of one of the propagative stolons—*a*, "colletoderm"—*b*, corallum—*c*, ectoderm—*d*, endoderm.
5. Spermatic capsule of reproductive polyp of male polypary—*a*, ectoderm—*b*, muscular coat—*c*, endoderm—*d*, gelatinous plasma, in which spermatozoa are developed.
6. Ovarian capsule of reproductive polyp of female polypary—*a*, ectoderm—*b*, muscular coat—*c*, endoderm—*d*, ova.
7. Fecundated ovum segmented by yelk cleavage.
8. Larva studded with motionless "palpocils."
9. Young polypary and polyp.
10. Spiral polyps covered with large thread-cells.
11. Large and small thread-cells.

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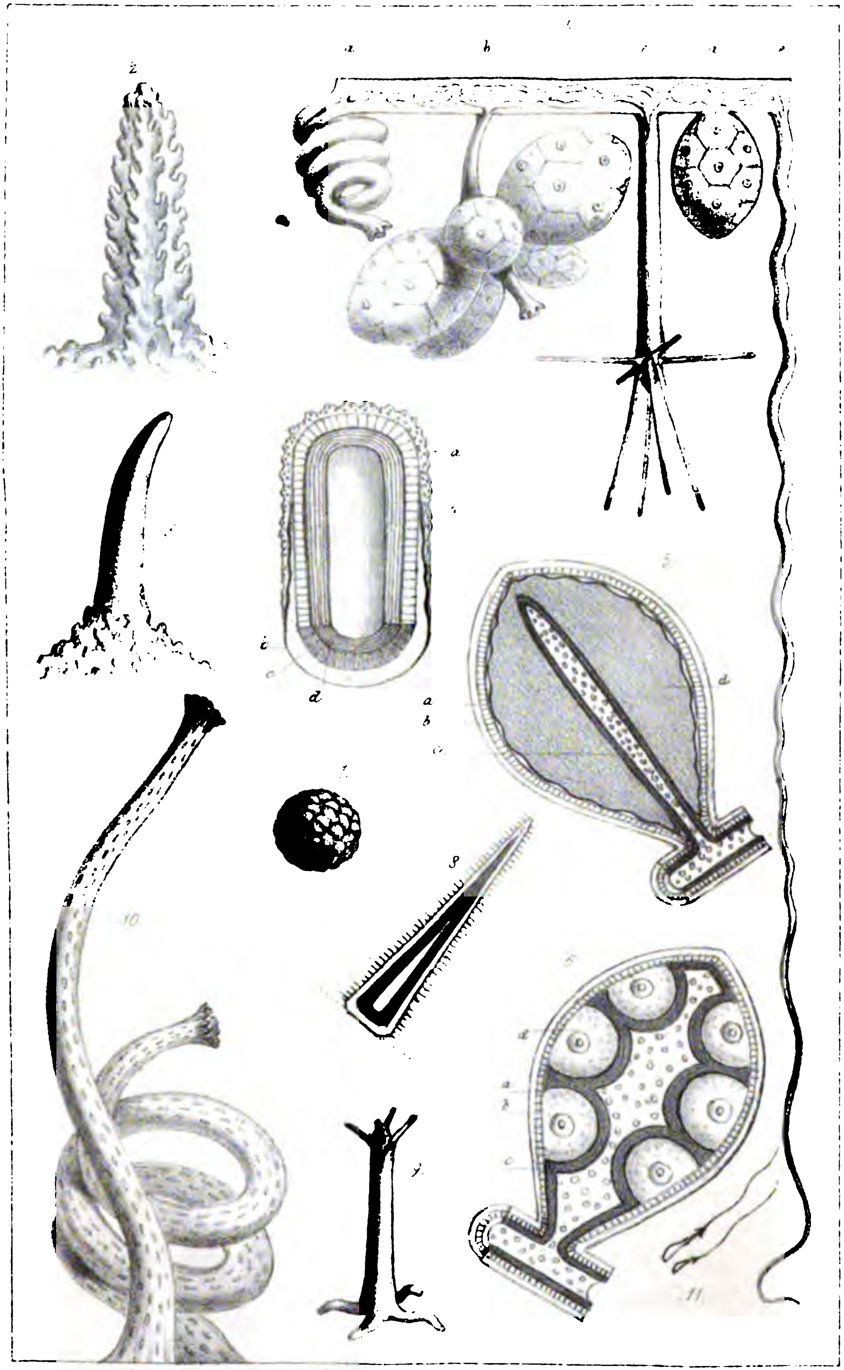
* Communicated to the Royal Physical Society of Edinburgh, Nov. 26, 1856.



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Hydractinia

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PLATE VI.

Fig. 12. Young polypary attached to side of tank, showing tubular net-work of the endoderm.

13. Diagram showing the situation of spiral polype *a*, and tentacular polyps *b*.

1. In rock pools left exposed by the retiring tide on the shores of the Frith of Forth, numerous Paguri, or hèrmit crabs are found, inhabiting old turbinate shells, formerly occupied by various species of Buccinum and Fusus. The rough and worn surfaces of these shells also form convenient homes for a great variety of animals, and frequently afford a strange scene of thronged and busy life. In the spring they present the naturalist with a rich field for observation. He will find the fixed and blind Balani, hidden in their mailed armour, winnowing the water with their fan-like cirri, and vomiting forth swarms of bright-eyed and actively swimming larvæ. There the Spio incessantly tosses about her long arms; the Serpula expands its many-coloured branchial plumes; Lepralia and other Polyzoa display their vase-like crowns of ciliated tentacles; and forests of Zoothamnium (an arborescent vorticella resembling a miniature sea-fan) extend their branches and wheel-bearing heads, or quickly coil up their writhing stalks in a compact ball at the approach of danger. All these, and many other forms of life, hurried through the water on the house of the scrambling crab, doubtless profit by the constant renewal of the vital element, and partake of the good fare enjoyed by the eremite within.

2. One of the most frequent co-tenants of the abode of the Pagurus is the *Hydractinia echinata.* Shells infested by this zoophyte appear to be covered by a white shaggy fleece, which consists of a host of hydroid polyps, closely aggregated together as the stalks in a field of corn.

These polyps appear to be carelessof the rough motions of the crab, and wave loosely to and fro as it jolts along over the rocks; but when any part of the colony is rudely touched, the whole of the polyps contract *en masse,* and seem to sink down into the substance of the shell. A close examination shows that this consentaneous action on the part of the polyps is caused by their being all developed from a common membranous basis, which spreads itself in a continuous thin layer over the shell, and being intimately connected with their tissues, forms a bond of sympathy between the whole assemblage.

3. The subject of the present communication is by no means new to science. It has been treated of by Fleming, Johnston, Gray, Couch, Hassall, M'Gillivray, Van Beneden, and especially by Quatrefages, whose monograph on this zoophyte is replete with interest. After reading the memoirs of these philosophers, I became convinced that a complete conception of the morphology of Hydractinia had not been attained by any of them. This I had previously been attempting to work out by the examination of some hundreds of specimens, many of which had existed for months confined in glass vessels, and propagating themselves by stolons and sexual reproduction. The conclusions I have come to may be briefly stated as follows:—In Hydractinia, the polypary, or common connecting membrane is to be considered as an individual animal, possessing alimentary and sexual organs polypoid in form. Each polypary is unisexual or diœcious; male and female organs being never situated on the same polypary, or on the same *shell!* The polypary, in addition to its alimentary and sexual polyps, possesses additional organs of prehension and offence, hitherto undescribed, which have a determinate situation. It is also furnished with corallum or skeleton, which, although widely differing in form from the coralla of other hydroid zoophytes, is identical with them in chemical composition and mode of secretion.

Anatomy of Hydractinia.

4. A consideration of the anatomy of Hydractinia may be conveniently divided into three parts:

1st, The Corallum or polypidom, the horny skeleton of the zoophyte.

2d, The Polypary, or common body.

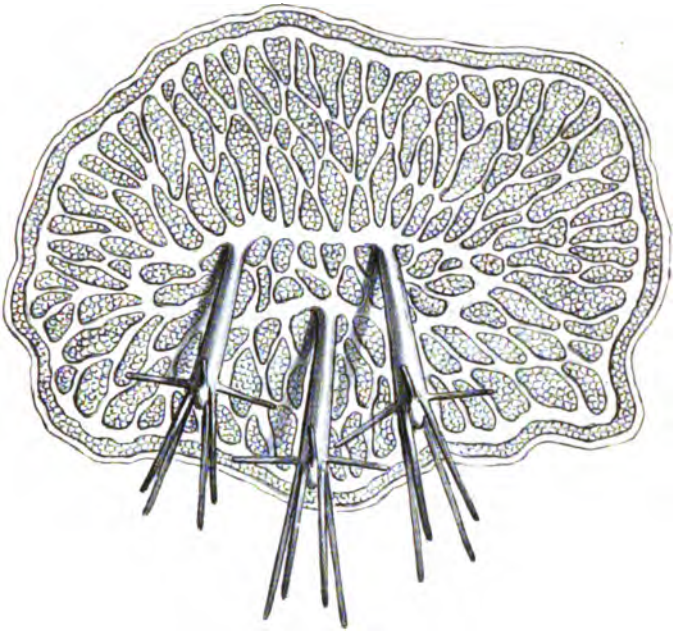
3d, The Polyps.

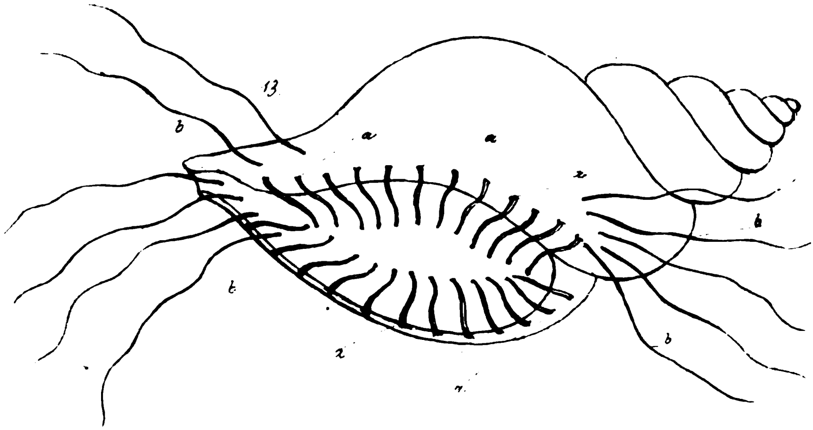
The Corallum.

5. *The Corallum* is a layer of transparent amber-coloured chitine; a substance having the consistence of horn, but differing from it in chemical composition. It closely invests that part of the shell inhabited by the zoophyte. Its struc-

PLATE 6

19.





T. Strethill Wright delt F. H. Weisse on stone Schenck & McFarlane, Lithrs Edinr

ture is very dense at the mouth of the shell, where it frequently (as remarked by Johnston) forms a slight extension of the whorl. As it passes backward, it gradually takes the form of a fine indurated membrane beset with spicules of irregular shape. Delicate and transparent casts of entire shells are thus occasionally formed, which may be removed uninjured by the aid of consecutive solutions of nitric acid and caustic potash. I have placed one of these on the table; and it will be seen that the surface, with all its parasitical growths, is copied with the fidelity of the electrotype. Over the more exposed parts of the corallum, the chitine rises up in the form of thickly set papillæ or spines, which have their surfaces furrowed by deep longitudinal grooves (fig. 2). The ridges between these grooves are coarsely lobed or serrated, and after passing from the summit to the bases of the spines, traverse the corallum, and unite with each other, and with the ridges of the neighbouring papillæ, so as to form a raised network, intersecting the surface in every direction. The structure of many of the spines differs somewhat from that above described; some being hollow smooth cones, slightly grooved or reticulated only at their base (fig. 3); while others have their ridges pierced everywhere by foramina, and united by irregular transverse bands, until they become a mere fenestrated structure of interlacing fibres. More rarely, we find the spines here and there fused together in long serrated ridges, running parallel with, or fitting into each other in a variety of intricate patterns. Quatrefages has described the corallum as an endoskeleton deposited in the substance of the polypary, like the solid axis of Gorgonia. But I am satisfied that his views on this point are incorrect, and that its mode of secretion differs in no essential from that of the corallum of other hydroid zoophytes.

The Polypary.

6. The polypary consists of a layer of semi-transparent fleshy matter (either colourless, or tinted with light shades of yellow, buff, or pink), which invests the corallum, and fills up the grooves of its papillæ, the interstices between its reticulations, and the cavities of its hollow spines. It is often absent at the summits of the papillæ, and is so thin over their

ridges, that the serratures appear through it as fine undulating lines.

7. *The Polypary* is the most important part of the zoophyte. It secretes the corallum, renews it when injured, and extends it along the shell. From it the polyps are developed; and it represents the trunk by which the whole assembly are united to form a single plant-like animal.

8. Quatrefages states, that the polypary is underlaid by a network of tubular fibres, which pass between the polyps, and unite their alimentary canals with each other. The existence of this structure has been doubted by Dr Johnston, and altogether denied by Van Beneden; but I have repeatedly detected the tubes *permeating*, rather than underlying, the polypary, and have watched their development day by day, in portions of that body growing over a transparent surface.

9. In the less exposed parts of the shell the polypary frequently passes beyond the papillary corallum as a thin membranous expansion, or breaks into a loose network of delicate anastomosing tubes, which traverse every cranny and furrow of the shell, and can only be detected after their tissues have been coagulated by immersion in alcohol. On these, polyps are developed at long intervals; and in the larger tubes an intermittent circulation of shining globules may be detected by the aid of high microscopic power and direct sunlight. In specimens which have been long kept in captivity I have seen these fibres throw up thick white stolons or suckers, tipped with crimson, some of which have attached themselves to the sides of the tank, expanded themselves into independent polyparies, and afterwards put forth clusters of polyps. The small living specimen on the table, of which fig.12 is a drawing, has been propagated in this way, and shows the tubular structure of the polypary in an admirable manner.

10. The life of the polypary is not dependent on the presence of the polyps. Many specimens of Hydractinia occur in the winter, in which the polypary exists in a high state of development, although its polyps are very few in number, or altogether absent, and which nevertheless become clothed with these organs on the return of spring.

11. The minute anatomical structure of the polypary, the nature of its connection with the corallum, and the mode of

secretion of the latter, cannot readily be investigated in those specimens of Hydractinia which are parasitic on the shell of the Pagurus, as the zoophyte is broken up by an attempt to remove it from its site. A better opportunity for observation is afforded when the animal has extended itself along a transparent surface. The propagative stolon of Hydractinia, after leaving the point of its origin, increases rapidly in diameter, and throws out irregular branches, not unlike a very minute specimen of *Tubularia larynx*. The tips of these branches are covered with a glutinous cement, by which they attach themselves tenaciously to glass or other surface near them. Having attached themselves, they expand laterally, at the same time throwing out finger-like prolongations, which, as they come in contact with each other, coalesce, until a fleshy plate is formed adherent to the glass. Polyps are developed both from the loose branches and the attached polypary; and the latter is clearly seen to be permeated by a beautiful system of anastomosing canals (fig. 12) connected with the hollow bodies of the polyps. Within these canals may be detected an intermittent flow of fluid, containing particles, the dancing motion of which indicates the presence of ciliary action, and which, having passed in one direction for a short time, are arrested, and, after a slight period of oscillation, commence to flow in an opposite direction.

12. A few branches of one of the tubular stolons was submitted to a microscopic power of 600 diameters. They were found to be composed (fig. 4), as is the polypary of every hydroid zoophyte, of an external and internal membrane,—the "ectoderm" (*c*), and "endoderm" (*d*) of Allman,—inclosed in a wide tube or corallum of transparent chitine (*b*). At the growing extremities of the branches the corallum was absent, and its place supplied by an epidermis (*a*), a soft, glutinous layer closely investing the ectoderm.* Further down the branch the corallum appeared, secreted by the ectoderm beneath the epidermis, by which last substance it continued

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* This layer which I have called the "colletoderm," (κολλητης glutinator), is constantly found covering the coralla of creeping zoophytes, where it frequently forms a coat of considerable thickness, continued, also, as in Coryne, over the body of the polyp.

coated, and from which it derived its adhesive property. A delicate chitinous investment may also be detected on the creeping tubular fibres from which the stolons of Hydractinia take their rise; but I have not satisfied myself as to its presence on the entire upper surface of adult polyparies. In specimens of Hydractinia, however, growing in the shell, we find that the spines of the corallum, although varying in shape and structure, may be classed in two divisions; the one, solid and deeply grooved, and clothed by the polypary (fig. 2); the other, smooth, conical, and hollow, and inclosing a process of the polypary in their interior (fig. 3).

13. From the above observations, I conclude that the polypary of this zoophyte consists of a single layer of endoderm, inclosed between two layers of ectoderm. That the *lower ectodermic layer*, as it grows over the shell, attaches itself by its "colletoderm," and secretes the horny plate of the corallum. On this plate, by a further process of secretion from the lower ectoderm, the *grooved* spines are erected. That the *upper layer of the ectoderm* is naked over the greater part of its surface, or only covered by a thin epidermis; but occasionally this layer also takes its share in the secretion of the corallum, and in that event produces the smooth, conical spines, the concavity of which it fills.

14. I have been unable to detect the existence of true cells either in the endoderm or ectoderm of the polypary. These membranes appear to consist essentially of structureless modifications of elemental tissue, more or less vacuolated, similar to that we find in the protozoa, and to which the term "sarcode" has been applied by Dujardin. Accordingly, we find that the finger-like processes given off at the borders of the polypary constantly flow into each other when they meet, like the prolongations of sarcode projected from the pores of the Rhizopoda, or the outer layer of Actinophrys.

15. The walls of the tubes which permeate the polypary are frequently loaded with the coarse granular matter of a brown-yellow or crimson colour, which is found in the endodermic tissue of all hydroid polyps. This matter has been considered by some authors as a glandular secretion of the nature of bile. It appears to me to be identical with the brown matter which

exists in the bodies of many of the Protozoa, such as *Vorticella campanulata*, and which in other species of the same genus is replaced by a substance having all the properties of chlorophyll. In the *Hydra viridis*, also, we find green globules possessing the chemical reactions of chlorophyll substituted for brown matter in the endoderm. Whatever purpose this granular matter may serve in the economy of the hydroidæ, it always occurs in excess in situations where the vital functions are most actively carried on; such as the tips of growing stolons, the alimentary tubes of the polyps, and the ovaries and spermatic sacs.

16. *The Ectoderm of the Polypary* contains great numbers of the highly refractive capsular bodies to which the terms "tricho-cysts," "thread-cells," or "stinging organs," have been applied. They are of two kinds (fig. 11), differing very distinctly in size; the larger exceeding the smaller ones by about a diameter and a half. In shape they resemble somewhat a grain of wheat, being respectively flattened and slightly rounded on opposite sides. They are contained within small cells in the ectoderm, and possess dense coats, which, under pressure, burst at one extremity, and protrude a four-barbed dart, from the point of which projects a long stiff thread or hair (fig. 5). These thread-cells, found extensively in all classes of polyps and acalephs, are, I have no doubt, true organs of offence, as I have detected numbers of them plunged beyond the barbs in the soft bodies of worms, rescued from the grasp of *Hydra vulgaris*. But it is to be remarked, that they frequently exist in situations where their mischievous properties are rendered innocuous by the dense coverings under which they lie hid. Thus we find them congregated in masses on the polypary, beneath the thick corallum of *Coryne glandulosa* (Dalyell); and in *Halecium Beanii*, while the naked polyps are armed with unbarbed thread-cells of the most minute and simple kind, these bodies attain a giant size and formidably spinous development of the thread beneath the hard coverings of the reproductive capsules and the corallum.

The Polyps.

17. The polypoid appendages of Hydractinia are of five kinds (fig. 1):—

1. The Alimentary Polyps, possessing mouth and tentacles (*c*).
2. The Reproductive Polyps, destitute of mouth, and having only rudimentary tentacles (*b*).
3. The Sessile Ovisacs and Spermsacs of the Polypary (*d*).
4. The Ophidian, or Spiral Polyps (*a*).
5. The Tentacular Polyps, or great Tentacles of the Polypary (*d*).

18. *The Alimentary Polyps.*—These organs, which represent the prehensile and digestive systems of the zoophyte, first make their appearance as a thickening of the endoderm in one of the canals of the polypary, attended with a copious deposit of red granular matter. This thickening in a few hours rises from the surface in the form of a fleshy stem, on the summit of which an oral aperture presently appears surrounded by four small pullulating tentacles. When perfectly formed, these polyps are about half an inch in length, club-shaped, and furnished with from eight to thirty tentacles, placed in two alternating rows. Those of the upper row, which are about twice the length of the lower row, are held nearly parallel with each other above the mouth, while the lower row are extended at right angles to the axis of the body,—an exaggerated state of a disposition frequently observed in Sertularian and Campanularian polyps. The mouth opens into a buccal cavity, contained within a more or less elongated papilla, which rises in the centre of the circle of tentacles. This papilla is exceedingly distensible, frequently expanding itself into a wide discoid sucker, as shown in the figures of Quatrefages, and even folding itself backwards, so as to conceal the tentacles, and completely evert the body. A similar habit has been observed by Dr Coldstream in the polyp of *Clava*, and by myself in *Coryne pusilla*.

19. The body of the polyp consists of the same elementary tissues as the polypary, with the addition of a muscular tunic, which is interposed between the endoderm and ectoderm.

20. *The Ectoderm* of the alimentary polyp is a transparent, homogeneous membrane, containing molecular matter, also transparent, but of higher refractive power; so that expansions of this tissue have a finely-dotted appearance under the highest powers of the microscope. The ectodermic layer also contains multitudes of thread-cells of the *smaller kind*. These

are amassed in the greatest numbers at the upper parts and ends of the tentacles. Over the site of each thread-cell a very delicate soft spine or cilium may be observed projecting from the ectoderm, and apparently springing from the thread-cell itself. Similar spines exist over the smaller thread-cells of *Hydra vulgaris*, and those of Sertularian and Campanularian polyps. Now, when the thread-cells of these hydroidæ are displaced by gentle pressure, so as not to burst them, they are found to have a perfectly smooth contour. Moreover, the ectoderm of the planarioid larva of Hydractinia is thickly studded with these spines before any development of thread-cells has taken place. These spines also occur in various tribes of the mollusca; for instance, on the very adhesive tentacles which fringe the inner edge of the mantle of Lima, and on the tips of the branchial papillæ of Eolis. I am led to conclude, therefore, that they are tactile prolongations of the ectoderm, analogous to the prehensile processes of Actinophrys, or the long rays of Podophrya, and that their function is probably to distinguish and seize the prey, and to convey the stimulus necessary to effect the rupture of the death-dealing thread-cells immediately beneath.*

21. *The Muscular Coat* consists of a layer of closely-set, ribbon-shaped fibres, passing upwards from the polypary to the tips of the tentacles, so as to form a continuous tunic between the endoderm and ectoderm more transparent than either. It shows no indications of transverse striæ; but it exercises considerable depolarizing power on polarized light,—a property possessed by both striated and unstriated muscular fibre. There can be little doubt that all the tissues of the polyp have the property of slow contractability; but the muscular tunic appears to be specially adapted for the quick withdrawal of the polyp body between the sheltering spines of the corallum.

22. *The Endoderm* of the polyp is a finely-granular opalescent tissue, darker by transmitted light, and whiter by reflected light, than the ectoderm. Its appearance differs so remarkably in various polyps of the same polypary, that the

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* As these processes have not been hitherto noticed, I propose to distinguish them by the appellation of "palpocils."

observer might, with Quatrefages, be induced to represent it as a compound of many different tissues. In its simplest form, as it generally occurs in the reproductive polyps, it is a structureless membrane, similar to the ectoderm, deeply loaded with coloured granular matter, and ciliated on its internal surface. In other polyps the endoderm is extensively vacuolated, or filled with cavities, until it appears to consist of a congeries of cells of every variety in size. In a third class, again, the vacuolation is still more extensive. Here the membrane has the appearance of being split into two layers, one of which forms an intestinal tube, occupying the axis of the body, while the other lines the muscular tunic; the two being intimately connected by an areolar network of fibres, or septa, or irregular cells. The endoderm of the tentacles possesses a similar variety in structure. I have not been able to satisfy myself of the existence of a canal in their interior.

The internal surface of the endoderm has the function of nutrition; its external surface that of reproduction.

23. *The Reproductive Polypoid Organs* (fig. 1. *b*), male and female, are always situated on separate unisexual polyparies.

24. The *Male Polyp* is smaller than the alimentary polyp. The buccal cavity and mouth appear to be absent; but I have occasionally seen the place of the latter marked by a whitish spot, through which I have succeeded in forcing the contents of the intestine. The tentacles are merely small protuberances, thickly studded with the *larger* thread-cells, which bodies also occur over the whole surface of the polyp. The parietes of the body consist of the same three elements as that of the alimentary polyp. Their middle third is dilated into a sac, from which numerous diverticulæ protrude, to form spermatic capsules (fig. 5). The endoderm of the sac and capsules is richly ciliated, and loaded with brown granular matter; and between all the communicating cavities a constant circulation of fluid, charged with globules of sarcode, takes place with a powerful rotatory turmoil. At first, all the coats of the capsules are in close apposition to each other; but, as they increase in size, the endoderm (*c*) becomes widely separated from the other coats, by the secretion from its outer surface of a dense transparent gelatinous matter. The transparency of this matter, after a time, becomes obscured by the

formation within it of innumerable minute cells, from each of which a single spermatozoon is presently developed. After a time, the endodermic layer of the capsules having been reduced by absorption to a mere linear core of brown matter occupying the axis of the capsule, and the spermatic mass having become liquid and white, the latter is at last evacuated from an opening in the summit of the capsule, and descends through the water as an expanding cloud.

25. *The Female Polyp* resembles the male in its form and the development of its generative capsules. But at an early stage of the development of the capsule, from four to nine ova make their appearance between the endoderm and the other coats, in place of the gelatinous matter secreted in the capsules of the male polyps (fig. 6). These ova, at first consisting of a small transparent vitellus, containing a germinal vesicle and germinal spot, become of an opaque yellow, white, or crimson colour, by the granulation of the yoke, and rapidly enlarge, until the female polyp is almost hidden under the mass of immense ovaries with which it is burthened.

26. *The Sessile Generative Sacs* of the polypary are developed from the tubes of the polypary itself. They resemble exactly those of the reproductive polyp, and contain ova and spermatozoa in the polyparies of different sexes.

27. *Three kinds of reproduction* may be observed to obtain amongst the hydroid zoophytes:—1st, *Polypiparous*, where the young is discharged from the ovarian capsule in the complete form of a polyp, as in Tubularia; 2d, *Larviparous*, where the young are born as ciliated planarioid larvæ, as in Clava, or simple unciliated germ-masses, as in Coryne, afterwards becoming polypoid; and 3dly, *Oviparous*, where true ova are discharged from the ovarian sacs, and the subsequent changes into planarioid and polypoid forms take place after their leaving the parent zoophyte, as in the subject of this paper.

28. *In Hydractinia*, the ova, after extrusion from the ovary, and their having undergone fecundation by the spermatic fluid of a male polypary, become segmented (as in fig. 7) by the usual process of yelk-cleavage, and are transformed into transparent fleshy masses, in which may be detected the rudiments of the endodermic and ectodermic tissues.

These masses presently become developed into taper cones (fig. 8), which attach themselves by their bases, travel along the surface of the glass in which they are kept, and congregate on the side next to the light, like a forest of tiny masts. They consist *of an ectoderm*, destitute of thread-cells, but thickly studded with the soft spines I have before mentioned (19), and tenaciously adhering to any body brought in contact with them; *and of an endoderm*,—crimson, granulated, and not vacuolated, inclosing a cavity which occupies the axis of the cone along its whole length. Many of these larvæ have lived for several weeks with me without undergoing any further change; others have in a few days been developed into small four-tentacled polyps (fig. 9), and protruded creeping tubes from their base,—the rudiments of the future polypary.

29. Quatrefages has figured the male or sperm capsule of Hydractinia, and mistaken it for a reproductive "bulbil." Johnston also falls into a similar blunder. Van Beneden, again, has described the male and female polyparies as distinct species, under the name of *Hydractinia lactea* and *rosea*.

30. *The Ophidian, or Spiral Polyps* (fig. 1, *a*, fig. 10, and fig. 13, *a*). I can scarcely express the surprise I felt on discovering these remarkable organs. I was examining a specimen of Hydractinia, from which the crab had been removed, when I found a number of bodies, like small white snakes, closely coiled in one, two, or three spirals, and grouped immediately round the mouth of the shell (fig. 13, *a*). These bodies, when touched, only drew their folds more closely together. But if any part of the polypary, however distant from them, was irritated, the spiral polyps uncoiled, extended, and lashed themselves violently backwards and forwards, and then quickly rolled themselves up again; and that not irregularly or independently of each other, but all together, and in the same direction, as if moved by a single spring. A violent laceration of the polypary caused these polyps to remain extended and stretched like a waving and tremulous fringe across the mouth of the shell for several minutes. The Ophidian Polyps (evidently a barren modification of the re-

productive polyp) are never found in any other situation on the polypary than in that before described, or round the margins of accidental holes in the shell. They have no mouth, and the tentacles are rudimentary. The walls of the body are very transparent, from the extreme vacuolation of the endoderm. The muscular coat, as might be expected from the active movements of the polyps, is highly developed, and forms a beautiful object on the dark polarized field of the microscope, each spiral coil shining out as a bright double ring, divided by four dark sectors. The ectoderm of the whole body and tentacles is crowded with the larger thread-cells. The ophidian polyps are, I doubt not, organs of defence or offence, like the motile spines and bird's-head processes of the Polyzoa, or the pedicellariæ of the Echino-dermata; but I am unable to assign a reason for their peculiar situation. They vary much in number and size in different specimens of Hydractinia, but are rarely altogether absent.

31. *The Tentacular Polyp*—(fig. 1 *e*, and fig. 13 *b*).—Not less surprising than the polyps last described are these, the great tentacles of the polypary. When a specimen of Hydractinia is allowed to rest suspended in a glass jar of water, these organs are extended to a distance of three, four, or even five times the length of the alimentary polyps, and hang down, loosely floating in the water, like the thread-like tentacles of the long-armed hydra. They are found on the outskirts of the polypary, and on each side of the long diameter of the mouth of the shell, so that they must, in their natural condition, reach to the ground, and enable the zoophyte to seize food scattered there by the feeding crab. The tips are covered with a dense pavement of the larger thread-cells; and a few of the same bodies are thinly scattered along their whole length. As far as I know, no organ analogous to them exists in any other hydroid zoophyte. They have not been hitherto described.

32. In our consideration of the subject of this communication, our attention is arrested by the multitude of objects grouped together to constitute a single animal, their variety in form, and the sympathy which subsists between the different parts. The singular spinous skeleton; the expanded membrane of the polypary, with its beautiful internal network of

tubes and delicate peripheric prolongations; the alimentary polyps, some white and filiform, others thick, fleshy, crimson, or yellow sacs, obligingly everted, to expose their interior to our microscopic eye; the reproductive polyps, with their richly-coloured generative sacs; the sessile generative organs of the polypary; the ophidian polyps, coiled in neat spirals when at rest, but starting into furious action, like a row of well-drilled soldiers, when injury is inflicted on the body to which they are attached; and lastly, the tentacular polyps, floating in the water like long and slender threads of gossamer, or dragging up heavy loads of food for the common good; these, together with the intimate relation and sympathy subsisting between the polypary and its associated organs; all combine to form an object of the highest interest, and indicate that in this fixed, yet travelling zoophyte we have a type of structure transitional between the dendritic hydroidæ and the more highly organized acaleph. In the simplest acalephoid form, such as the medusoid of Campanularia (which is nothing more than an extension of the polypary specially organized for independent and motile life), we have (as in Hydractinia) an expanded polypary, represented by the umbrella, and permeated by vascular tubes, from the confluence of which last spring, *at the centre*, the single alimentary polyp; *at the periphery* the tentacular polyps, various in number; and between them the reproductive polyps, represented by the sessile generative sacs. In the higher Rhizostomes we find, as pointed out by Huxley, a multitude of alimentary and reproductive organs, united by ramifying tubes, which permeate a massive swimming polypary. In other acalephæ, such as *Velella*, *Porpita* and *Ratraria*, we probably have a still closer resemblance to Hydractinia, in the development of a corallum, represented by a horny plate, which in the last of these medusæ elevates the crest, serving as a sail by which the floating mass is propelled before the wind along the surface of the waves.

33. In conclusion, I must mention that Hydractinia is infested by a small species of Eolis (*Eolis nana*), which peels off the polypary with its rasp-like tongue, and devours it,—possessed, I suppose, of some potent magic, which renders all the formidable armament of its prey of no avail. Now, each of the

dorsal papillæ of the Eolidæ contains at its extremity a small ovate vesicle, communicating, through the biliary sac, with the digestive system, and opening externally by a minute aperture at the end of the papillæ. This vesicle is found crowded with compact masses of thread-cells; which masses, in *Eolis nana*, consist of aggregations of small and large thread-cells, identical in size and shape with those of Hydractinia,—on which this Eolis preys—not contained in capsules, but cemented together by mucus. When we consider that each of the vesicles is in indirect communication with the stomach, I think we may, without presumption, suggest a probability that the masses of thread-cells found in *Eolis nana* are *quasi* fæcal collections of the thread-cells of Hydractinia, which, protected by their strong coats, have escaped the digestive process. In corroboration of this view, I may mention that the thread-cells of *Eolis papillosa*, as figured in the work of Alder and Hancock, have a perfect resemblance to those found in the Actinias, which last animals furnish an Abyssinian repast to these carnivorous mollusca.

Description of a Self-Registering Maximum and Minimum Arrangement for the Syphon Barometer. By THOMAS STEVENSON, F.R.S.E., Civil Engineer.

At a meeting of the Council of the Meteorological Society of Scotland, held on 11th July last, I exhibited and described a self-registering syphon barometer, of which I now venture to give a more detailed description.

Several forms of self-registering barometers have been published, among which may be mentioned Hooke's in 1685, Dr Traill's in 1830, the late Mr R. Bryson's in 1843, and the photographic register, which has been more recently introduced. Those of Hooke and Bryson are so constructed, I believe, as to preserve a constant register of the oscillations of the mercurial column, and are therefore of a far more complete nature than the instrument I am about to describe. Excepting Dr Traill's, all those barometers require, however, a somewhat complicated system of clock-work, which to a great extent precludes their adoption, unless in regular observatories. Dr Traill's is different from the others, and resembles mine in

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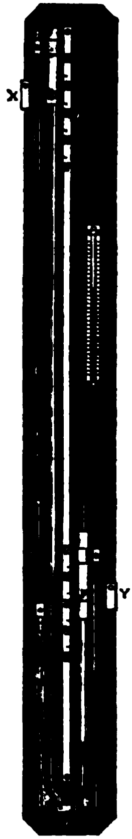
only registering the maximum and minimum readings, but it requires the employment of two distinct barometers.



I have endeavoured to attain the registration of the maximum and minimum pressures of the atmosphere during any given period, by the use of attached magnets, in the following manner:—Let *a*, *b*, *c*, represent a common syphon barometer. *e* and *g* represent the graduated scale of the ordinary kind. They are so divided that, by adding together the readings of the heights of both the surfaces of the mercury, the total length of the mercurial column, which at any one time balances the terrestrial atmosphere, is at once ascertained. Such is the arrangement for a common syphon barometer. In this instrument, however, there is another scale, *d f*, having a *fixed* zero point, which is ascertained by comparison with a standard barometer. The height of the barometer can therefore be at once got by a single reading on either limb, without any arithmetical process. For example, when the atmospheric pressure balances 30 inches, the surface of the mercury in the long limb should stand opposite to the mark 30 on the scale which is attached to that limb, while the surface of the column in the lower limb should also stand opposite to the mark 30 on the scale adjoining the lower limb. The divisions on this supplementary scale will, however, of course, be only half as large as those on the common scale, where the height of the mercury is ascertained by two readings. *x* and *y* are two small floats of watch-spring, or of soft iron. These floats are made excessively thin, for the sake of being light, and thus they offer but small resistance to the movements of the mercury, on the surface of which they float.* *x* and *y* are two small magnets, having spring clamps which slip stiffly along the side of the wooden framing of the barometer, and are placed so as to be opposite to what may be called the *working parts* of the tube, or those parts in which the variation of the mercury takes place. By moving the magnets up or down a little, the floats can be brought to rest on the surface of the mercury. The instrument is then ready for action. If, during the absence of the observer, the barometer should rise, the mercury will raise the float in the upper limb, while the float in the lower limb being arrested by the attached magnet, will be prevented from following the sinking of the mercury in that limb. If, after having attained its maximum height, it should then begin to fall, it will leave the upper float at its maximum level. In this way the observer will, on his return, be able at once to see how high the barometer has stood during his absence. If, on the other hand, the barometer should have stood lower when he was absent, the minimum reading will be got from the float in the lower limb, which will be higher up than the surface of the mercury. Thus the maximum readings will be registered by the float in the long limb, while the minimum readings will be registered by the float in the short limb.

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* I have recently prepared for the lower float a thin vertical piece of iron, stuck into a thin slice of cork, which rests on the surface of the mercury. It might also be an improvement to make the horizontal part of the upper float of glass instead of metal,—a plan which has already been used for metallic indices.

I may here observe, that, owing to a curious, and, so far as I know, an unexplained electrical action, the upper float, or that which is *in vacuo*, often adheres with sufficient force to the sides of the tube to render the use of the magnet unnecessary for the maximum readings.

In order to insure accuracy in the working parts of the tube, a small piece of tube was selected, which was found to be of uniform bore. This piece was broken into two equal portions, which were then joined to the opposite ends of a longer tube, of a length sufficient to make up the proper length for the barometer. As the working parts of the tube need not together exceed about three inches, there is little or no difficulty in getting a piece of such limited length of uniform bore. In this instrument there is of course no correction for temperature, although this could be attained in some degree by having two fixed zero points for the small scale, the one being suited to a mean of the summer, and the other to a mean of the winter temperature. With the syphon form of barometer there should be no correction either for capillarity or capacity.

I regret being unable to give a register of the indications afforded by this barometer, as the mercury had, shortly after I got the instrument, been unfortunately, as I suppose, brought into contact with some metal, with which it formed an amalgam, thus causing the lower surface to become so viscid as entirely to vitiate the indications. Another barometer was being made for me by our late excellent optician, Mr John Adie, whose lamented death has prevented its completion. I may mention, that a *similar application of magnets may perhaps be found useful in getting maximum and minimum readings with other instruments than the barometer;* and it was very much this consideration which induced me to draw up this brief notice.

Notice respecting Father Secchi's Statical Barometer, and on the Origin of the Cathetometer.[*] By Professor FORBES.

A friend, who returned lately from Rome, has sent me some copies of a pamphlet by Father Secchi of the Collegio Romano, one of which I lay on the table of the Society.

It describes a barometer stated to be on a new construction. The barometric tube is suspended from one arm of a balance, and counterpoised. It is filled with mercury in the usual way; but the cistern into which it opens is fixed apart, and does not move with the beam of the balance. It is evident, therefore, that the varying pressure of the air on the exterior of the tube will require a changing counterpoise, and that the magnitude of the change may be increased by enlarging the section of the tube, so that the alteration of pressure may be indicated with any required delicacy.

It is also obvious that, to use this barometer, the tube does not require to be transparent, but may, for instance, be made of iron; only the internal section must be uniform throughout the range of pressure.

The idea of thus measuring barometric pressures appears so obvious that it is not likely to be really new. But I had also, when I read the paper, a distinct recollection of having seen it described many years ago.

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[*] Read to the Royal Society of Edinburgh, 16th March 1857.

After a slight search I found it, accordingly, under the name of the *Steelyard Barometer* (the tube being suspended from the shorter arm of a steelyard, while the other points to the angular deviation on a scale), in Rees,' and others of the older Encyclopædias (as in the earlier editions of the *Britannica*), in *Hutton's Mathematical Dictionary*, and in *Gehler's Wörterbuch*. But, what is singular, no inventor is assigned to the contrivance, except in the last-named work, where it is described generally as Morland's, though Hutton, who is there cited as the authority, says nothing of it.

In *Desagulier's Natural Philosophy* (1763), an experiment with a balance, similar to Father Secchi's arrangement, is described and figured, but it is not referred to as a construction available for practical purposes. This might lead one to believe that the contrivance was more recent than Desagulier's time. But, after considerable search, I found, in the nineteenth volume of *Rozier's Observations de Physique* (1782), page 346, a curious historical statement by Magellan, which refers the contrivance to Sir Samuel Morland, who, it is there stated, presented it to Charles II. Magellan does not, however, give his authority for this, stating, on the contrary, that he found no mention of the contrivance in any of the authors who had treated of the subject, but that he had seen two of these instruments. One of them, made by Adams in 1760, belonged to George III; and I think it possible that it may still be found amongst the instruments of the Kew Observatory. The other was made by the celebrated Sisson, and came into M. Magellan's possession; a careful figure of it is given in the work just cited. It is perhaps likely that the ascription of it to Morland, and the story of its presentation to Charles II., was a tradition among the London instrument-makers. It may, however, be recorded in some of Sir Samuel Morland's writings, which I have not found either in the College or the Advocates' Library, and in which it does not appear that Magellan had himself seen it.

I have as yet been unable to trace the steelyard modification of the statical barometer to its origin. I think it likely to be an independent invention.

Of course these remarks are not intended to infer the smallest doubt of Father Secchi being the inventor of the instrument which he describes. Of that there can be no question; and the application of it, which Father Secchi proposes, to the purposes of self-registration, makes it a well-timed resuscitation of an almost forgotten contrivance, which yet appears to date from the same century with the invention of the barometer.

2d March 1857.

Postscript—*16th March* 1857.—I have not succeeded in throwing any further light on the true origin of the statical barometer. On writing to Mr Welsh of the Kew Observatory, I find that King George III.'s curious collection of apparatus has been long dispersed. I ought perhaps to add, with reference to Father Secchi's contrivance, that he recommends in some cases the *cistern* of the barometer to be made movable, instead of the tube. The balance is then disturbed by the efflux of mercury from the tube of the barometer when the pressure diminishes, and by its influx when the pressure increases. Though less elegant, as an application of a principle, it has the advantage of making the suspended mass lighter. It will be seen, by a reference to Magellan's account of Sisson's instrument, that the weight was such as to require support on friction—rollers instead of knife edges.

Invention of the Cathetometer.—I take this opportunity of adding a historical notice, which has occurred to me whilst making the preceding inquiry. In the twentieth volume of the Philosophical Transactions for 1698, Mr Stephen Gray described a microscope moving on a vertical pillar by means of a micrometer screw, to be used for determining the exact variations of level of a liquid, such as mercury in a barometer or thermometer, and not necessarily connected with the apparatus. This instrument accurately corresponds in most respects with that known to French physicists and instrument-makers under the name of the *Cathetomètre*, which I have never heard ascribed to any inventor in particular, and which, till very lately, has hardly been recognised in this country.

On the Reproductive Economy of Bees; being an Account of the Results of Von Siebold's recent Researches in Parthenogenesis. By Professor GOODSIR.*

The term Parthenogenesis—the production of young by a virgin —*lucina sine concubitu*—was introduced by Professor Owen, to designate "the successive production of procreating individuals from a single ovum;" and, as understood and employed by him, this term is not only distinctive of those peculiar forms of propagation which had previously been generalized by Steenstrup under the phrase, "alternate generation;" but is also expressive of their essential character. It is not proposed in the present communication to examine Professor Owen's doctrine of Parthenogenesis, nor to attempt to determine to what extent it legitimately involves all the remarkable phenomena which it professes to express and elucidate; but to state briefly the remarkable results of observations on the subject made by another Physiologist, whose name is a sufficient guarantee for the care and exactness with which they have been conducted.

Von Siebold of Munich published a few months ago a work entitled "Wahre Parthenogenesis, bei Schmetterlingen und Bienen"—Real Parthenogenesis, as it occurs in Butterflies and Bees. In his introductory chapter, after claiming for himself the previous announcement, in Müller's Archiv, for 1837, of the distinctive peculiarities of the reproductive organs of the oviparous and viviparous aphides, the author gives to the "alternate generation" theory of Steenstrup that place to which the influence it has already had on the science fully entitles it. He cannot, however, admit that alternate generation can be included under parthenogenesis, as has been done by Professor Owen. On the contrary, alternate generation and parthenogenesis are distinct, inasmuch as propagation *sine concubitu* in alternate generation occurs in sexless individuals; whereas propagation *sine concubitu* in parthenogenesis occurs in actual females.

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* The importance of the results contained in Von Siebold's work induced the author of this abstract to communicate it to the Royal Society of Edinburgh. He only became aware of the approaching publication of Mr Dallas' able translation of the work itself on the evening on which his own abstract was read.

While I admit the propriety, as I believe will be generally done, if such a form of propagation be confirmed, of limiting Professor Owen's expressive term parthenogenesis to propagation by a female *sine concubitu*, or more precisely to development of an individual from an ovum into which no spermatozoon had previously entered, I must observe that Von Siebold has somewhat misunderstood Professor Owen in reference to the so-called aphides nurses. Although Professor Owen terms these intermediate forms virgins, and considers them to be females, he states that they do not possess spermathecæ and colleteria; and in support of this quotes Von Siebold himself, as reported in Froriep's Notizen. The difference in the views of Owen and Siebold regarding the aphides nurses is this—that the former believes them to be undeveloped females, which propagate "*in utero*," under the transmitted influence of "*an ancestral coitus*;" while the latter holds them to be sexless individuals, which propagate by internal gemmation.

Von Siebold next examines at considerable length the statements of the various entomologists who have asserted the capability of reproduction by unimpregnated females in certain species of Lepidoptera. He comes to the following conclusions: That due precautions had in no instance been taken to prevent the access of the male, remarkable, in this order of insects, for the instinctive sagacity and ingenuity of his approaches; and that all the observations had been accidental or indirect, and therefore destitute of the precision essential to such inquiries.

Notwithstanding these conclusions, Von Siebold could not avoid being influenced by the repeated assertions of the existence of parthenogenesis in the genus *Psyche*. Although the established facts, that the footless and wingless females of this genus are impregnated within the sac, and again enter the chrysalis case in order to deposit their eggs in it, and that the footed but wingless females of the genus *Fumea* are impregnated on the upper surface of the sac, but deposit their eggs in the chrysalis case left within it, might appear to cast much doubt upon any assertion of parthenogenesis based on the fact of the eggs being deposited in such a locality; nevertheless there appeared to be such indications of its actual occurrence, more particularly in the restricted genus *Solenobia*, as warranted special inquiry.

Siebold was indebted to Reutti, an able lepidopterologist in Freiburg, for numerous sacs of *Solenobia lichenella*, Lin., and of *Solenobia triquetrella*, F. v. R., gathered in that neighbourhood; and he himself collected around Berlin, in 1850, 1851, and 1852, many hundred sacs of both genera. To his great astonishment all these sacs produced females, with the exception of two from a single locality, which produced males. These sacs were kept and observed in small vessels closed with glass plates, so that no males could have access to them. The females, after leaving the sacs, and dragging their pupa-cases out along with them, clasped firmly the exterior of their sacs, and, to Von Siebold's great surprise, speedily began to deposit their eggs in the latter.

In this respect these *Solenobiæ* females differed from those of the genus *Fumea*, which, if excluded from the male, would remain attached to the exterior of their sacs until they died, without depositing a single egg. So powerful was the impulse of these *Solenobiæ* females to lay their eggs, that, if slightly removed from the sac, they would stretch their ovipositors towards its aperture, and drop the eggs on its exterior. But if Siebold was struck with the egg-laying propensity of these virgin females, he was still more astonished to find that the eggs produced larvæ, which, with the greatest eagerness, endeavoured in every direction to procure materials for the manufacture of their sacs.

At this stage of the inquiry Siebold, although satisfied that these Lepidoptera are capable of reproduction *sine concubitu*, was inclined to believe that these apparent females were only sexless individuals, as in the case of the aphides nurses. He found, however, on dissection, that they possessed the characterisic reproductive organs of the female moth. The anterior orifice opened into a fully developed but perfectly empty bursa copulatrix and receptaculum seminis, while the posterior communicated with well-stocked ovaries. These *Solenobiæ* were, therefore, fully developed virgin females.

The *Solenobiæ* are not the only ascertained representatives of parthenogenesis among the Lepidoptera. *Psyche helix*, a species which has been carefully investigated by Von Siebold, and of which the female only has been with certainty recognised, affords an equally surprising example of virgin procreation. The larva of *Psyche helix* is a leaf-burrowing, sac-bearing caterpillar, feeding on *Artemisia Vulgaris*, *Anthyllis Vulneraria*, &c. Siebold named the species from the form of the sac, which, about the size of a pea, and consisting of aglutinated particles of earth, is wound spirally two whorls and a half to the left, and, like some other insect structures of the same kind, had been mistaken for the shell of a mollusc. When the caterpillar is feeding, the mouth of its spiral sac covers the orifice made in the epidermis of the leaf, while its margin is applied against the surrounding uninjured epidermal surface. Its body is spirally curved, and, when full grown, occupies only two complete whorls. It evacuates its fæces through a lateral orifice, situated at the junction of the incomplete with the second whorl of the sac. When about to pass into the pupa form, it leaves the plant on which it has been feeding, and spins the mouth of its sac firmly to the surface of a stone or rock. The butterfly itself is destitute of wings and antennæ, its feet are feebly developed, its body spirally bent, its movements inert, but its reproductive organs fully matured. She deposits her eggs in her pupa husk, within the spiral sac, and having then shrunk to a comparatively small size, comes out of the sac by the lateral orifice left near its apex, for this and other purposes, by the instinct of the larva; after leaving it she speedily dies. Siebold does not admit that the male of *Psyche helix* has been discovered; but as it must be admitted that the females of this, as of the other species of *Psyche*, are impregnated within the sac, and that the act must be effected through the lateral orifice, the abdomen of the male is probably spirally curved in a corresponding manner.

By keeping the spiral sacs of *Psyche helix* under glass covers until the larvæ had passed through their pupa stage, and until the eggs deposited by the imagos had produced larvæ, Von Siebold satisfied himself that, in this species of insect, the ova may be developed without the influence of spermatozoa.

With reference to the sex of the Lepidoptera producing *sine concubitu*, it appears extremely probable, from the rarity or apparent deficiency of males, that it will turn out to be female.

While engaged with the parthenogenesis of the Lepidoptera, Von Siebold entered on the investigation of the numerous conflicting questions and statements regarding the reproductive economy of the bee. With this view, he put himself in communication with various bee-masters, but more particularly with Herr Dzierzon, a clergyman at Carlsmarkt, in Silesia; and, with the

Baron von Berlepsch, of Seebach, in Thüringia. The most important result of these personal inquiries was a new theory of the reproductive economy of the hive, propounded by Dzierzon, which involved and explained, in the most satisfactory manner, all the hitherto inexplicable genetic mysteries of the bee colony. The anatomico-physiological verification of this theory constituted the greater part of Von Siebold's labours in this department of his subject.

Herr Dzierzon had recorded his hypothesis as early as 1845, in Barth and Schmid's "Bienen Zeitung;" and also in 1849, in his work on the "Theory and Practice of Bee Farming."

Dzierzon's hypothesis is to this effect—that although the queen, or perfect female bee, in order to be fully fitted for her position in the hive, must be impregnated by a drone or male bee during her marriage flight; yet nevertheless, those eggs from which drones are developed are not impregnated. It is admitted that an unimpregnated queen bee may produce drones; and that even working bees, which are incapable of sexual conjunction, may occasionally deposit drone eggs. The spermatheca alone is impregnated during the flight of the queen bee; the ovaries are not affected. The queen, after impregnation, retains the power she previously possessed of depositing drone or unimpregnated eggs; but she can also thereafter deposit impregnated eggs, from which alone working bees and queens can be developed.

In proceeding to the verification of Dzierzon's theory, there are certain fundamental physiological facts in the economy of the hive to be kept steadily in view.

The young unimpregnated queen is never impregnated within the hive, but always on the wing, high in the air. As Dzierzon's hive permits, for the first time, every part of the hive, and every side of each comb to be minutely examined, and as every effort has been made, without success, by experienced observers, to detect the impregnation of the queen bee within the hive, it may now be safely assumed that it takes place only during flight. This mode of impregnation occurs in many other insects; but in the Hymenoptera it is peculiar in the rapidity with which it is effected. Von Siebold examined and dissected a queen bee sent to him by Baron Berlepsch, taken immediately after her return from her marriage flight. He found the male organs detached and retained in connection with her bursa copulatrix, and her spermatheca full of spermatic fluid. Leuckart has also proved that the intromittent organs of the drone can only be protruded during flight; and that they are so protruded, not by muscular or erectile arrangements, but by the pressure applied to them from within, by the distension of the abdominal tracheal pouches during flight.

Von Siebold had already proved that the spermatic fluid deposited in the spermatheca *in coitu*, retains during, or nearly to the close of the life of the queen bee, its characteristic or essential spermatozoa. He had also shown that the spermatheca is provided with voluntary muscular fibres, so as to enable the animal to retain or evacuate its spermatic contents. These facts are in accordance with, and therefore tend to support, the second position assumed in Dzierzon's theory—*viz.*, *all the eggs which come to maturity in both ovaries of the queen bee, are of one kind, which, if deposited without having come in contact with spermatic fluid, are developed into drone or male bees; but if impregnated by spermatic contact, are developed into female bees, that is, into working or queen bees, according to their subsequent treatment.*

It will be at once perceived that this position, while it completely resolves all the difficulties which have hitherto obstructed every attempt to explain the reproductive economy of the hive, is in direct opposition to what has hitherto been considered a fundamental physiological law, *that an egg, whether it be developed into a male or a female, must have been previously impregnated.* Von Siebold has nevertheless satisfied himself of the truth of Dzierzon's assumption by extended indirect as well as direct evidence.

Experienced bee-masters know the evil consequences which follow from a queen born with defective wings. She cannot take her marriage flight; but her impulse to deposit her eggs is unrestrained. She lays them in the working cells and drone cells in apparently the usual manner; the working bees feed the resulting larvæ, which, however, being all drone larvæ, those which are in working cells become too large for them, these cells require to be altered, and the economy of the hive becomes disarranged.

Berlepsch instituted a very interesting experiment on this point. At the end of September, when the drones were all dead, he got a virgin queen to deposit eggs, which produced drones in the succeeding year. This queen was dissected by Leuckart, and found by him to be unimpregnated. The acknowledged fact, that working bees occasionally produce drone eggs, is explained by, and powerfully supports Dzierzon's hypothesis. Madame Jurine proved anatomically that the working bee is not a neuter, but an undeveloped female. And Baron Berlepsch has lately afforded Leuckart an opportunity of dissecting two drone-producing working bees, and of verifying the results of the Baron's own dissections. Five or six tubes were found in each ovary full of perfect eggs; but the colleteria and spermathecæ were so feebly developed that they were at first overlooked by Leuckart, and supposed to be absent.

It occasionally happens that towards the close of the career of a queen bee, spent in depositing in the normal manner drone and working bee eggs, she deposits drone eggs alone. This circumstance is explained by, and supports Dzierzon's theory. For the queen bee undertakes the marriage flight only once in her lifetime; and it may be fairly assumed that when she closes her career by producing drones only, her spermatheca has become empty.

Dzierzon's doctrine involves also the position that *the queen bee has the power to deposit at will male* or *female eggs*,—that is, *unimpregnated* or *impregnated eggs.*

The discovery, by Siebold, of voluntary muscles in the structure of the spermatheca in the queen bee, is explained by and supports this position. When she inserts the extremity of her abdomen into a cell, she ascertains, by the sense of touch, whether it has been prepared for a drone or for a worker. If it is a drone cell, she contracts the orifice of the spermatheca, and the egg passes out unimpregnated. If it is a working cell, she contracts the spermatheca itself, and the egg is smeared in its passage. That the queen bee possesses the voluntary power of depositing male or female eggs, appears also to be proved by the fact, that by means of a Dzierzon's hive, she may be induced to deposit either kind of eggs, by supplying her with the corresponding combs.

With reference to this part of the subject, two observations made by Baron Berlepsch are of importance.

While endeavouring to confine a queen bee in a small box, he accidentally bruised the extremity of her abdomen. She laid afterwards, as before, many thousand eggs, but they were all male. He unfortunately lost her, and could not ascertain by dissection the nature of the injury by which the spermatheca had been affected. It had probably, as Siebold suggests, been torn off or detached.

Von Berlepsch's second observation is still more important. Müller having shown that spermatozoa, after having been subjected to a freezing temperature, do not again regain their locomotive powers, but are in fact destroyed, Herr Berlepsch placed three impregnated queen bees for thirty-six hours in an ice-house. One of them recovered, was restored to her people, and deposited afterwards, as before, many thousand eggs in working cells; but *they all produced drones.*

Two varieties of bees are cultivated in Southern Germany; the German bee, with a dark brown abdomen, and the Italian bee, with a yellow abdomen. These two varieties produce, by mixture, what are termed bastard forms. Baron Berlepsch has investigated these bastard bees, with the view of ascertaining how far they afford support to the reproductive theory of Dzierzon. The results obtained by him are briefly these:—An Italian queen impregnated by a German drone bee, or *vice versa*, produced invariably—1. Females, purely Italian in colour; 2. Females, purely German in colour; and, 3. Females, of mixed colour; but the drones produced were all invariably of the colour of the mother. An Italian mother only produced Italian males; a German mother only German males.

In the present phase of physiological science, nothing short of direct proof can be admitted for the establishment of a doctrine so startling as that by means of which Dzierzon explains the genetic economy of the hive. It must be shown that spermatozoa invariably enter the female eggs through their micropyles; and that spermatozoa do not pass into the drone eggs.

Leuckart made the first attempt to verify the doctrine, by means of the microscope. He proceeded, in May 1855, to the residence of the Baron Berlepsch, at Seebach, and after having examined many females, and a greater number of drone eggs, his results were unsatisfactory and doubtful. He could find no spermatozoa on the male eggs; but, on the other hand, he only detected them in four or five instances on the micropyles of female eggs.

Von Siebold visited the Baron for the same purpose at a less favourable season—at the end of August of the same year. He began by accustoming his eye to the microscopic examination of the bee's egg, and by ascertaining the best mode of bringing its contents into view. This he found to be, as is generally the case, a very simple and ordinary procedure, to compress the egg set on end, by means of the thin glass cover, so as partially to evacuate its contents. On the 22d August, at 10 A.M., he commenced the examination of a comb with female eggs, which had been deposited one hour previously. On the same day he examined female eggs deposited twelve hours previously, and on the two succeeding days eggs which had been deposited fifteen hours previously. The result was, that in the empty space left in the egg by the evacuation of its contents under the micropyle, from one to three or four motionless or lively spermatozoa were found in almost every specimen which had been successfully compressed.

He experienced some difficulty in procuring a satisfactory number of drone eggs. But he examined with great care twenty-seven male eggs deposited twelve hours previously, and failed in finding, either on their exterior or interior, the slightest trace of seminal animalcules.

Von Siebold, therefore, considers himself fully entitled to conclude, that the females of certain Lepidoptera, and the males of the bee, are developed from unimpregnated ova.

REVIEWS AND NOTICES OF BOOKS.

Results of a series of Meteorological Observations made in obedience to instructions from the Regents of the University, at sundry Academies in the State of New York, from 1826 *to* 1850 *inclusive. Compiled from the original returns and the annual reports of the Regents of the University.* By FRANKLIN B. HOUGH, A.M., M.D. Published by Legislative Authority. 4to. Albany, 1855.

It is generally known to those interested in Meteorology that methodical observations, principally of the thermometer and rain-gauge, have for many years been in progress at numerous academies of the State of New York, and that the results of these have from year to year been published, and pretty extensively circulated by the Regents of the University in that State. These observations, though far from complete, according to our present notions of completeness, contained a vast body of interesting matter; for unquestionably the meteorological element of Temperature is by far the most important of all, while it is the easiest obtained, the instrument being of simple construction, and capable of being observed with small chance of mistake. The rain-gauge is also a simple instrument, and its results are of great practical consequence.

Amongst sixty-two Observatories, many of them comparatively remote, it is not to be supposed that indifferent, and even careless, observations may not occur. But the number is so considerable, compared to the area of the earth's surface on which they are situated, that by combining the results in groups, or by selecting the most obviously trustworthy, a very correct idea can be obtained of the mean temperature of this part of the globe, of the distribution of heat and cold over the different seasons, and of the humidity of the climate.

Such data are the more important, because, not long before these observations were commenced, scientific as well as practical men were only beginning to understand the fact of the widely different laws of temperature which prevail in the Old and New World, to which, perhaps, Baron Humboldt first distinctly called attention. The following little table will illustrate the difference of climates of America and Europe in nearly the same parallel of latitude.

	Latitude.	Temp. Year.	Hottest Month.	Coldest Month.	Diff.
New York,	40°·43	51°·6	73°·1	34°·3	38°·8
Naples,	40·52	60·3	76·3	46·2	30·1

Thus we see that the mean temperature of Naples exceeds that of New York by nearly *nine degrees*, and that the difference of monthly temperature at New York exceeds that of Naples by almost the same quantity. If we took the extreme range of the thermometer, we should find the excess vastly greater in the New World. To put it in another light, the temperature of New York is nearly the same as that of the south coast of Cornwall, which is *ten degrees* of latitude more northerly. After all, the city of New York, being near the sea, is one of the most *temperate* climates of the State. The value of these thermometrical observations has been sufficiently recognised. Professor Dove, in his researches on climate, has used them extensively.

In the volume before us we find the results collected in a commodious form, superseding the necessity of referring to the reports for individual years. This good service has been performed at the expense of the legislature, who voted no less than 3000 dollars for this purpose, an example worthy of imitation by our own government, who have as yet shown much apathy with regard to any attempts to explain the meteorology of Great Britain, although willing to second the efforts of merely nautical men in this direction.

The introduction to the work before us explains that when an improvement was contemplated in the form of registers to be adopted in future, the opportunity was thought a good one to collect the more important results of twenty-five years' observations on the old plan.

We have here, therefore, in the first place, the monthly averages of temperature, rain, and the direction of the wind, for every successive year, and for each of the sixty-two academies or institutions. These occupy 460 pages. A condensed summary of the whole then follows, and gives the most important results within the space of a very few pages, and in immediate juxtaposition.

From these tables, we learn that the mean temperature of the whole State is 46°·74, not very different from that of Edinburgh. The mean monthly range (which is the average of the extreme ranges during a given month for the whole period of years) amounts to 67°, and the mean annual range, or the average of the differences of the extremes of each year, 103°, which must be under the mark, as self-registering instruments were not generally used. At every station, except one (Oyster Bay), the thermometer has fallen below zero of Fahrenheit during the period embraced by the observations; and at sixteen of the stations it has exceeded 100°. The highest temperature recorded is 105°; the lowest—40° (at three stations); which is the lowest that could be correctly measured, if the thermometers were mercurial (as is probable). The extreme range of temperature in the State for twenty-five years was therefore *at least* 145°; and what is remarkable, several of the stations show a range nearly of this amount (Gouverneur, Lowville, and Washington [Salem] all 140°), the greatest cold and heat occurring usually in the same places. These facts give a lively impression of the *excessive* character of one even of the maritime States of America.

The average direction of wind throughout the State is S. 80° W. The mean aspect of the sky (showing a remarkable variety in different localities) gives an almost exactly equal number of clear and cloudy days in the course of the year. The average amount of rain in the States is 34·9 inches. June and October are the two wettest months. But at the maritime stations the largest quantity falls in spring. An account of auroras observed both in America and Europe concludes the work.

Advanced Text-Book of Geology. By DAVID PAGE, F.G.S. Blackwood. 12mo. 1856.

In our remarks on Mr Page's Introductory Text-Book of Geology, we felt called upon to notice certain errors in the author's arrangement of stratified deposits and grouping of fossils. Mr Page received those remonstrances in an excellent spirit, and, in a second edition, corrected the mistakes of the first. It is, therefore, with unfeigned pleasure that we record our appreciation of his "Advanced Text-Book of Geology." We have carefully read this truly satisfactory book, and do not hesitate to say that it is an excellent compendium of the great facts of geology, and written in a truthful and philosophic spirit. There is, however, one serious objection to the commencement of his tenth chapter. He almost entirely ignores the Cambrian system of Professor Sedgwick. Now, the highest authorities on geology, Sir C. Lyell, Professor John Phillips, and Professor Rogers of America, &c., consider that the Cambrian system requires a *distinct and independent grouping* from the Silurians, and that the Lower Silurians terminate with the base of the Llandeilo rocks. Mr Page must be aware that the "*hard lines*" drawn by many geologists are rapidly vanishing, as brighter light illuminates the still indistinct records of Palæozoic ages, or he would not have warned his readers so frequently "against the error of attaching to groups, and systems, and periods, a value that does not properly belong to them." The acknowledgment of the Cambrian system by the distinguished authors already mentioned should have induced him to admit a nomenclature long since established, and which to cashier altogether is absolutely UNJUST.

"It is true," we read (p. 274) "that the general facies of the plants and animals that lived during the Silurian epoch, differs considerably from the facies of the Devonian flora and fauna; but it is not true that the strata we call Silurian imbed a system of life altogether DISTINCT and DIFFERENT from that imbedded in the strata we term Devonian."

Let this reasoning be applied to the CAMBRIAN ROCKS. The division of Silurian and Devonian strata is convenient, although some of the organic forms *are identical*, and pass into both systems; and we are not aware that *Trenicola didyma*, *Palæopyge Ramsayi*, or either of the species of *Oldhamia*, are found in the Silurian rocks at all. If Mr Page classes the Cambrian deposits as lower Silurian strata, simply because trilobites occur in them, he should extend the term upwards, and include the carboniferous; for trilobitic crustaceans range in those rocks also!

Modern geologists and writers on geology would do well to remember what they owe to the "Principles," and that the "Silurian System" was for years, at least throughout Europe, the sole guide on Silurian geology. Again, no geologist has done so much to unravel those rugged strata termed Cambrian as Professor Sedgwick, or deserves higher acknowledgment at the hands of the rising disciples of the science. The hard-working and active-minded Professor is not so vigorous as formerly, and those who have profited so much by his assiduity and experience should be especially careful to render honour to whom honour is due.

Report on the United States and Mexican Boundary Survey. By Major W. H. EMORY, 1st Cavalry U. S. Army. (U. S. Boundary Commissioner.)

The first volume of this interesting Report has been printed, but owing to delays in the engraving of the valuable maps designed to illustrate it, it is not yet published. Having recently perused the printed portions of the work, and been permitted to inspect the maps and illustrations in the office of the Boundary Survey in Washington, we propose to give our readers a brief sketch of its scope and character. Perhaps there is no survey executed under the direction of the government of the United States,—if we except the admirably organized and conducted Coast Survey,—which, for accuracy and breadth of research, promises to contribute so much to our knowledge of the geography of the Continent, as this important exploration along the extended Mexican frontier of the country. Nor are its contributions to the Natural History of the interior of the continent of less relative value than its Geographical and Astronomical results.

We propose, after sketching concisely the history of this survey, to state the nature of some of its contributions to science, under the general heads of Astronomy, Geography and Climatology, Geology, Botany, and Zoology.

The war between the United States and Mexico resulted in 1848 in a treaty of peace, which aimed at defining a new boundary between the two countries; but in tracing that boundary, a difference of opinion arose among the officers of the United States Government employed to run the line, and the work was virtually suspended. It appeared that no interpretation of the treaty was compatible with a boundary line which would permit a ready communication between the United States military posts and settlements on the River Gila, and those on the Rio del Nortó; or, in other words, a practicable road between the Pacific and Atlantic slopes of the United States,—only wide desert plains, and rugged barren mountains, scarcely passable, lying along the projected frontier. The two governments therefore concluded a new treaty in 1853, which adjusted all disputed points, and defined such a line of boundary as was supposed, at the time, to include a practicable route for a common road, or even a railway, across the continent.

The boundary line now successfully traced coinciding only in part with the line agreed upon in 1848, may be defined as follows: It commences at the mouth of the Rio Bravo del Nortó (usually called in the United States, Rio Grande), runs thence up that river to its intersection with the parallel of 31° 47′ north latitude; thence, along that parallel 100 miles; thence, due south to the parallel of 31° 20′; thence west to the 111th meridian of longitude measured from Greenwich; thence, in a straight line, to a point on the Rio Colorado, 20 miles below the Gila; thence, up the middle of the Colorado, to a point near its junction with the river Gila; and thence, in a straight line, to a point one marine league south of the Port of San Diego.

To Major Emory was assigned duty on the first boundary line, as chief astronomer and surveyor, and under the last treaty he was appointed the commissioner in addition to his other duties, the government combining the whole into a military organization. The entire survey has therefore been conducted under his direction, and to him and his assistants we are indebted for the ample mass of information embodied in the Report and maps, now soon to be published.

This Report consists of four parts, in two large quarto volumes, and is divided as follows:—Part I. embracing the personal narrative with description of the country, and the Astronomical results; Part II. the Geology; Part III. the Botany; and Part IV. the Zoology.

The maps are of three classes; 1st, a General Map on a scale of $\frac{1}{6,000,000}$; 2d, four maps for military purposes, on a scale of $\frac{1}{600,000}$; 3d, a series of 53 maps, on a scale of $\frac{1}{60,000}$; and, 4th, a series of maps on a scale of $\frac{1}{6000}$, representing the islands and special localities, and the features according to which they have been assigned to the respective countries. The maps of the 3d and 4th classes are not to be published, but are to go into the archives of the government.

There are about 300 illustrations, including those of objects of natural history. Among them are views along the parallels of latitude, enabling the line to be hereafter identified, should Indians or others remove the monuments erected along it. Besides these, there are several profiles, exhibiting the undulations and altitudes of the surface, and others constructed as geological sections, to represent the stratification of the country.

Astronomical Results.—The entire length of the boundary-line following the sinuosities of the rivers, is upwards of 2000 miles. When it is considered that a very large portion of this vast space is travelled by bands of hostile Indians, it must be obvious that a trigonometrical survey was not practicable. The next most accurate method for adoption was that of linear surveys, checked by astronomical observations. Nine or ten principal points were selected as primary stations, and their exact places determined by elaborate observations, for longitude on the moon and moon-culminating stars, and for latitude on stars near the zenith; the instrument used being a 46-inch telescope made by Troughton and Simms. Intermediate points were then determined by transmission of chronometers, by occultations and eclipses of the satellites, and by all the means resorted to which give results of a secondary degree of accuracy. In tracing the parallels, the latitude was determined every 15 or 20 miles, and the ordinates to the parallel measured from the prime vertical, which was determined by measurements of the elongation of Polaris, made with the best Gambey theodolites. The reductions for longitude were made, in all practicable cases, from corresponding observations, most of which were furnished by Professor Airey of the Greenwich Observatory, and for which Major Emory gratefully acknowledged his obligations at a meeting of the American Association for the Advancement of Science, held in Washington in 1854, the Association voting thanks to Professor Airey.

Among the more valuable of the astronomical results may be stated,—the determination of 208 points in latitude and longitude, extending entirely across the continent, most of them not previously ascertained, even within approximate limits. That the astronomical work has been conducted with extreme care and attention to accuracy, is shown in the fact, that the table of the latitudes obtained by using the zenith telescope developes very distinctly errors in the declination of many stars, as given in the Catalogue of the British Association.

The catalogue, known as the "Twelve year Catalogue," of more recent date and greater accuracy, could not be advantageously used, because of the limited number of stars recorded in it; and therefore the much more comprehensive British Association Catalogue was employed.

Two Geoditic lines, of very considerable extent, were determined in connection with this boundary. The first connects the initial point on the Pacific with the junction of the Gila and Colorado, and has a length of 148 miles. The second, ranging from the point on the Colorado, 20 miles below the junction to the intersection of the 111th meridian of longitude with the parallel of 31° 20′, has a length of 237 miles. As the nature of the country, especially its want of water, and of the means of subsistence, precluded all hope of uniting the extremities of each line by triangulation, it was resolved to establish the latitude and longitude of each point by direct observation on the heavenly bodies, and compute the azimuth of the line connecting them. So nicely were the observations made, that when the parties charged with tracing the first line upon the ground met in the Desert, north of the Colorado, they were within 100 feet of each other.

A portion of the country adjacent to the United States and Mexican boundary was examined by Major Emory in 1846, and some of the results of this reconnaissance have, through an error of the venerable Humboldt, been accredited to Abert and Fremont, neither of whom had explored the region till after this eminent author had published the edition of his (Aspects of Nature) in which the allusion is made. It is but justice to mention, that the astronomical determinations made during that reconnaissance with the sextant have not been changed by the more elaborate observations since undertaken with instruments of a higher class.

Physical Features.—We cannot, in this brief sketch, offer a connected description of the remarkable topographical features of the country intersected by the boundary line, nor more than allude to the great table-lands, and chains of mountains arising from these. Their influence is all-controlling, whether we view it in its physical or social relations. No student of the physical geography and climatology of the continent can find his way to an interpretation of their phenomena without acquainting himself with the structure of this region; nor can the statist measure at all the probable future progress of population without gaining first a close understanding of its topography.

This exploration has called for important changes in the map of this part of the continent. Following the line of the boundary inward from the Gulf of Mexico, we pass a belt of lagoons separated from the sea by a chain of low, sandy islands and marshy flats. The firmer land bordering the lagoons is, for the first ten or twenty miles, a flat, verdant prairie, formed of alternating river and marine deposits. West of this low plain are salt lakes and tracts encrusted with white saline efflorescences, and devoid of vegetation. More generally there is a clothing of high luxuriant, coarse grass, interspersed with clumps of the live or evergreen oak. Passing the belt of prairie, there is seen a ridge of low sand-hills, apparently an ancient coast-line or sea-margin. This steppe, extending many miles into the interior, has a sandy, calcareous soil, the washings of the wide cretaceous formation, which spreads hence to the centre of the continent. The soil itself is unsurpassed in productiveness, wherever the vegetation finds a sufficiency of moisture; but between the Nueces and the Rio Bravo del Nortó, a great deficiency of rain renders agriculture extremely precarious. Indeed, when we approach the Rio Bravo, the aridness becomes excessive, and the natural vegetation, in adjustment with it, is that of a semi-desert country, consisting largely of the Cactaceæ and other spinous plants. Large tracts to the west and south of the Nueces, are, however, richly covered with grass, and here are to be seen countless multitudes of wild horses and cattle. Towards the Rio Bravo the surface is extensively cut by deep precipitous gullies, called Arroyos, which for many months contain not a drop of water, and again in the brief season of rains are the channels of wild, impetuous torrents.

In the more prosperous days of Mexico extensive reservoirs for water were kept up at certain stations throughout this deficiently-irrigated country, but these have gone to ruin. Throughout the entire valley of the Rio Bravo and its tributaries Indian corn can scarcely be cultivated, except in the low lands, susceptible of natural overflow or artificial irrigation. On the table-lands or Mesas, unsuited to cultivation, grow many semi-tropical plants, as Yuccas, Dasylirions, and Agaves, useful for their fibres; also leguminous shrubs and trees, furnishing gums, tanning, and nutritious pods. While the upper Rio Bravo is fed by the melting of the snows of the Rocky Mountains, the lower portion of the river receives only tributaries supplied by the tropical rains.

Ascending the gulf-slope of the continent westward, there succeeds an elevated plateau known as the Llano Estacado or Staked Plains, through the eastern terraces of which issue, by deep and narrow defiles, called Cañons, the attenuated sources of the Red River and other streams. Throughout a great portion of the year this table-land, which varies in elevation from 3500 to 4000 feet, is almost absolutely rainless. Perhaps the total rain-fall for the year amounts to 8 or 9 inches. Between the 102d and 106th meridians of longitude, a broad belt of mountain table-land crosses the Rio Bravo W. of the Pecos, ranging N.W. and S.E. It is this broad barrier which deflects the Rio Bravo at its great bend, the river flowing through a stupendous narrow ravine or Cañon between gigantic vertical walls for more than one hundred miles. These mountains rise to a great height near Monterey and Saltillo, and form, it is thought, the Sierra Madre of Nuevo Leon in Mexico. Still further west we meet other spurs of the Rocky Mountains, one main range of which subsiding in height near the 36th parallel of latitude and east of the Rio Bravo, crosses the boundary under the name of the Organ Mountains, near El-Paso, sinking to rise again and merge itself in the high table-lands of Mexico. This ridge, or chain of ridges, is by some geographers regarded as the Sierra-Madrè, or Mother Mountain, that is to say, the true water-shed of New Mexico; but Major Emory states that the Sierra-Madrè and the Rocky Mountains, about the parallel of 32°, lose their continuous character, and assume the forms graphically described in the western country as *lost mountains*, or mountains without apparent connexion. The ridges rise abruptly from the high plateau which supports them, and as abruptly terminate; so that, by winding around their bases, it is possible to cross the whole mountain system in the region near the boundary-line, or near the 32d parallel, almost on the plane of the table-land, and at a height not exceeding 4000 feet. This table-land, forming the backbone of the continent, attains its greatest elevation in Mexico, where it is nearly 10,000 feet above the sea, and it is an interesting circumstance, that its lowest depression is very nearly coincident with the parallel of 32°. Ascending thence from a height of 4000 feet, it undulates between 7000 and 8000 feet to near the 49th parallel, or the northern boundary of the United States, where it once more begins to sink. It was upon a hint supplied by the reconnaissance of 1846, of the existence of this remarkable transverse depression near latitude 32°, that the government of the United States instructed its minister, when negotiating the treaty of Guadalupe Hidalgo, not to take a line north of the 32d parallel as the boundary with Mexico.

Between the Rio Bravo and the head of the Gulf of California the general trend of the more distinctly marked mountain ranges rising above the great table-land of New Mexico, is N.W. and S.E. From the eastern edge of the plateau westward, to longitude 110, the principal ridges adjacent to or crossed by the boundary line, are the San Luis, the Guadalupe, and San Padro, in the order named. The San Luis Mountains, rising abruptly a little north of the line, and running south, appear to be by far the most massive chain in this latitude west of the Rio Grande. They are the Sierra Madrè Mountains of Sonora and Chihuahua, though it would appear that they are not on the very water-shed of this part of the continent, some of the Pacific rivers originating to the east of them, and flowing through them by gigantic chasms.

Geological Results.—The geological examinations made in connexion with the United States and Mexican Boundary Survey embrace a general reconnaissance of the formations illustrated by collections along the entire line from the Gulf of Mexico to the Pacific Ocean. Among the main facts elicited are the following:

The existence of a marine tertiary belt on both sides of the Rio Bravo, skirting the west coast of the Gulf of Mexico, but less developed in horizontal breadth and in thickness, than where it forms the low Plain of Louisiana, Mississippi, and Alabama. The interior limit is near San Antonio, or more strictly at Reynosa, where the tertiary strata are succeeded by the cretaceous. This latter great system of deposits, abounding in well characterized fossils, spreads continuously from near San Antonio, to the watershed between the Rio Pacos and the Rio Grande, which river passes through it by a series of gigantic cañons or profound ravines. The continuity of the formation is interrupted below the Presidio del Norté by prodigious masses of intrusive igneous rocks, which have variously inclined its elsewhere nearly horizontal strata. In some localities the nearly level beds are extensively covered with overflows of comparatively modern lavas. The Limpia Mountains contain various igneous rocks, such as recent lavas, trachyte, amygdaloid, and porphyry. On the western slope of this range we encounter the Carboniferous Limestone rising out from beneath the cretaceous, and dipping strongly towards the west. This limestone gives indications of metamorphism from heat, and is traversed by many outbursts of igneous matter. Hence to the eastern base of the Sierra Madrè the traveller meets a succession of mountain-ridges and plateaux composed largely of the carboniferous and other palæozoic rocks, supporting in the valleys and plains between them narrower isolated basins or shallow patches of the cretaceous deposits. The Sierra Madrè itself is characterized by igneous products not differing materially from those which occur in the Limpia range. As a mountain system it includes a great number of broken ridges, running, for the most part, N.W. and S.E., but tied together by transverse ridges, inclosing extensive basin-like plains,—the parched and formidable Jornadas (journeys or forced marches) of this district.

Advancing westward, the first extensive exhibition of the ancient plutonic rocks, granite, &c., and of the older metamorphic strata, gneiss, mica-slate, &c., is low down along the valley of the River Gila, where they occur first in isolated exposures, but further on constitute the main crests of the Cordilleras of California. North-east and east of the San Barnardino range, and west of the Colorado, occur wide beds of comparatively modern tertiary deposits, and other apparently still more recent tertiaries around the head of the Gulf of California. West of the Peninsular chain, or immediately bordering the Pacific, is a very narrow interrupted strip of tertiary strata, probably of several dates, but mainly Miocene.

Botanical Results.—The botanical collections of the Mexican Boundary Survey include a large mass of material, illustrating well the geographical distribution of plants throughout the long zone explored. The final revision of these is not yet completed, but enough is known to authorize us to state, that the new species, including those already published in the Plantæ Wrightianæ, pertaining properly to the boundary survey, amount to at least 500, embraced in some fifty new genera. The Cacti alone include fifty new species, presenting numerous examples of all the extra-tropical genera, Mammillaria, Echinocactus, Cereus, and Opuntia. The final Report will be richly illustrated with good drawings of the new species, and will contain much interesting information on their geographical distribution, treating also of the medicinal and economical uses of the plants of the district surveyed.

Zoological Results.—Though it is premature to attempt at present any detailed notice of the zoological discoveries connected with this boundary survey, the final determinations and special reports being not yet completed, we are justified in stating that important additions have been made to the recorded fauna of North America. Many species, either entirely new, or for the first time discovered within the limits of the United States, have been collected by the commission. The list includes about twenty-five species of mammals, fifteen of birds, sixty-five of reptiles, and eighty of fishes contributed to the fauna of the United States; of these at least, four-fifths are entirely new. Of serpents alone there are twenty-five species. Among the mammals may be mentioned *Felis Yagouarundi*, and *F. unicolor*, *Cervus mexicanus*, *Lacidea berlandieri*, also species of *Geomys*, *Neotoma*, and *Sigmodon;* among the birds, *Vireo*, *Dendrocygna*, &c.; the reptiles, *Heloderma*, *Dipsas*, *Crotalus*, *Ranhyla;* and among the fishes, families of *Characini*, and fresh-water *Labroidi*.

H. D. R.

CORRESPONDENCE.

To the Editors of the Philosophical Journal.

Gentlemen,—Of the celebrated men of science of the last century, there is one who holds a high rank as a discoverer, as a philosopher, in the best sense of the word, and as an historian of science, viz., Bergman. Amongst some letters which have lately come into my possession, there are several from this distinguished man. They had been preserved by my brother, the late Sir Humphry Davy. The mere circumstance of being kept by him, who was little in the habit of keeping letters, would seem to indicate the value he attached to them. They are all in the Latin language, and are all addressed to the same individual, a Dr Schwediauer, who, from the terms employed, was evidently an esteemed friend of their author. The short period they comprise is that of four years, from 1780 to 1784,—these, his last years, his death having taken place on the 8th July 1784, at the little advanced age of 53. In one of these letters, that of the 12th October 1781, it is worthy of remark, that he makes mention of a severe attack of hæmoptysis following the suppression of an habitual hæmorrhoidal discharge to which he had been subject—an attack from which he recovered with difficulty, and which probably shortened his life. Notwithstanding, I can find no notice taken of it by any of his biographers.

As examples of the manner in which men of science then corresponded, as well as on account of the reputation of the writer, and the topics which they treat of, I have selected five out of the sixteen in my possession as most likely to be interesting: these I inclose, venturing to indulge in the hope that you may consider them deserving of insertion in the *Edinburgh Philosophical Journal.*

Those of your readers who may not be well acquainted with the varied labours and discoveries of Bergman, will find, should their curiosity be excited, a pretty ample account of them, and of the particulars of his career of life devoted to science, either in Rose's Biographical Dictionary, or in the eleventh volume of the Philosophical Transactions, abridged, or more in detail in the second volume of Dr Thomas Thomson's History of Chemistry.—I am, gentlemen, your obedient servant,

John Davy.

Lesketh How, Ambleside, Nov. 14, 1856.

Celeberrime Domine Doctor.

Tuam 3 Julii scriptam epistolam nuper accepi, eamq. non sine singulari voluptate perlegi, quippe quæ novissima Chemiæ incrementa generatimq. hujus scientiæ in Anglia statum enarrat. Quod mea opuscula approbatione recipiantur, me non potest non delectare. Veritatem, ubi decet, candidus quæsivi, et ea, quam illis per totam Europam adquisivi benevolentiam, meos labores non prorsus caruisse successu, mihimet persuadet. Defectum exemplarium in Anglia eo magis ægre fero, quo certius naves hoc anno vestram insulam petituræ dudum abierunt, adeo ut, nisi inopinata occasione, plura apportari nequeunt citius, quam proximo vere. Tunc autem ut habeas operam dabo. Interea titulos Disserta-

tionum in secundo volumine occurrentium memorasse non forte displicebit. Primum undecim continet, secundum quatuordecim. xiima agit de formis crystallorum; xiiima de Terra silicea; xivma de Lapide hydrophano; xvma de Terra gemmarum; xvita de Terra Turmalini; xviima de Calce auri fulminante; xviiima de Platina; xixma de mineris ferri albis; xxma de Niccolo; xxima de Arsenico; xxiida; de mineris zinci; xxiiitia de Præcipitatis metallicis: xxivta de Docimasia minerarum humida; et xxvta de Tubo ferruminatorio, ejusdemq. in explorandis corporibus usu.

Dissertationes de Terris geoponicis et de pigmento indigo, in Gallia sunt impressæ, adeo ut non nisi unicum utriusq. exemplar possideam, sed in volumine tertio prodibunt revisæ una cum aliis de Productis vulcaneis, de Attractionibus electivis, de calculis animalium, et quæ sunt reliquæ. Immo huic volumini Sciagraphiam regni mineralis, secundum principia constitutiva digesti, inserendam cogito.

Laminam metallicam mihi missam examinavi, eamque præter cuprum et zincum vix quidquam continere reperi. Ferro caret et nihil aliud esse videtur, quam orichalci species, quæ ignita aquæ immergitur, ut fiat durior et magis elastica, has enim qualitates fusione fugavi et dicta operatione revocavi pro lubitu.

Observationes et experimenta Domini Crawford de igne lubenter legerem, nec non Domini Higgins de glutine murario, aliaq. novissima Chemiam quodammodo tangentia. Si cujusvis operis exemplar Domino von Asp, Legationis sueciciæ Secretario tradere. Tibi placeret, hic sine dubio prima occasione mittet. Quo Tibi lubet modo debitum solvam. Sveciam sero ingrediuntur libri anglici.

Quod a Domino Fontana mihi missum scribis, non accepi.

Experimentum cum Phosphoro vitrum corredente notatu est dignissimum et cito repetendum meditor. Sed forte vitri anglicani, quod multum plumbi continet, in hoc momento longe alia est ratio, quam nostri.

In dissertatione anno 1740 edita Dr Haupt salem vocat perlatum, qui in urina inspissata una cum sale microcosmico deponitur. Hic, uti jam notum est, constat alkali minerali, acido phosphori satiato.

In Medical Review, pag. 139, determinationem desideras canthari, at sequenti explicatione memet sine dubio sufficienter excussatum reperies. In experiundo Speciæ pondera et mensuras adhibui, pratereaq. supervacaneam cum exoticis comparationem duxi, quum hæc satis adcurata in Actis Academia Stockholmensis, ante plures retro annos translatis in linguam Germanicam, et postea quoq. in Latinam et Gallicam, occurrat. In volumine nemper septimo, pro anno 1746 pondera et in volumine sequente, pro anno 1747, mensuræ nostræ examinantur. Pes suecanus in volumine primo determinatur. Itaq. non potui non hæc præterire, quum eadem cognita crediderim.

Hac occasione plura scribere non vacat. Dum proxima vice mihimet scribis, epistolam extus ita signes.

To the Royale Society, at Upsal, in Sweden.

Intus vero ad initium adscribis: To Mr T. Bergman. Ceterum, anglica, vel qua Tibi libuerit lingua, scribas. Valeas, vir Celeberrime, optat.

Tui Nominis.
Dabam Upsaliæ, die 19th Sept. Cultor observantissimus,
anno 1780. T. Bergman.

Celeberrimo Experientissimoq. D. Doctori Schwediauer, S.P.D.
T. Bergman.

Epistolam tuam die 24 Octobris scriptam die 10 Dec. obtinui. Si nondum sarcinulam ablegaveris, quæ opuscula anglica mihimet destinata continet, eximas Scheelii tractatum de igne, quippe quem mihi misit D. Forster una cum itinere islandico translato, itemq., Dissertationem Domini Magellan, quam dono auctoris jam posideo, et Mülleri de Turmalinis Tyrolensibus, A. D. Boru, missam. Addas vero, si placet, quæ Priestleyus nuper edidit, cujus hactenus non nisi tria volumina de aëre adquirere potui. Sarcinula sine dubio adhuc restat apud D. Asp, adeo ut hæc permutatio facile peragi possit, et etiam quæ hac hieme imprimuntur addi, quum vix nisi primo vere eam mittendi occasio occurret. In proximis litteris memet instruas, quomodo inscribenda sit sarcinula, cum prima nave imminentis anni Tibi mittenda, ut illam Londini cito et tuto obtineas? Quædam ne desideras exemplaria Dissertationum, Opusculis licet dudum insertarum, si quæ forte supersunt primæ editionis specimina, seorsim edita? Opusculorum, vol. secundum, nondum Lipsiam attigit. Bibliopola Iversen, Lubecæ habitans, exemplaria per Germaniam divendendi curam in se suscepit, quæ dudum in ejus manus pervenisse spero. Est ne quidquam commercii Lubecam inter et Londinum? Facilius saltim, quam e Lipsia, exemplaria adquiri posse videntur si quædam desideras antequam proximo vere mihimet mittendi, occasio subministrari potest. Jam ad quæstiones propositas seorsim resolvendas memet confero.

Lacca sigillatoria cærulea e cæruleo Berolinensi, quod immisceatur gummi laccæ leniter fuso. N.B. instar ceræ dealbato, nam si flavet, viredo oritur. Hanc laccam sigillatoriam non ad candelæ flammam accendere licet, sed mediante idoneo æstu caute est fundenda, dum litteris claudendis inserviet. Vitrum cobalti similiter adhiberi potest.

Animalisatio telæ linteæ primo peragitur illam cum stercore vaccino recente probe fricando et in äere exsiccando. Dein tela lota pluries immergatur lixivio saponaceo e sale sodæ et pinguidine animali, præsertim cetaceorum, facto, et inter quamlibet immersionem solis exposita radiis exsiccetur. Hæc sunt momenta operationis cardinalia.

Sal ammoniacus acido constat muriatico per alkali volatile satiato, ubi notum est. Ut hic cum lucro confici queas principia habeantur oportet vili pretio. Sed aqua marina, separata per crystallisationem muria, multum continet magnesiæ acido salis satiatæ, adeo tamen laxe adherentis, ut solo calore destillatorio acidum sejungi possit. Hinc intelligitur ratio ob quam in confiniis maris arte facilius paretur sal ammoniacus. Alkali volatile ab ungulis et cornubus animalium obtinetur, nec non ab omnibus aliis animalium partibus.

Molybdæna vix novum continet metallum. Constat namq. acido quodam particulari sulphuri adunato. Quum arsenicum regulinum experimentis congruenter nihil sit aliud, quam peculiare acidum phlogisto satiatum, adeoq. sulphuris species, arsenicum autem album idem acidem tanto foetum inflammabili, quanto coagulationi (non saturationi) opus est, non sine magna probabilitatis specie credo, quodlibet metallum constare quodam acido radicali, quamvis hactenus a nullo acido metallico, præter arsenicale, phlogiston penitus evelli potuerit. In molybdæna præsens acidum, ni fallor, metallicum est, forte stanni. Plumbago longe alius est indolis, continens vix aliud quam acidum æreum et phlogiston.

Magnesia nigra minime eodem modo reduci potest, quo alia metalla. Methodum idoneam, in Opusc., vol. ii., descriptam invenies, vel, si desideras, alia vice in litteris communicabo. Descriptio Telluris physica secunda vice prelo subjecta est anno 1773. Annis 7 sequentibus multa didici, multa huc pertinentia ab aliis sunt detecta, quæ ideo desiderantur. Versionem secundæ editionis Germanicam nondum vidi : ut compares suecanum mittam exemplar.

Nonne in Officina Bentleyana imagines quorundum chemicorum et illustrium physicorum fingantur? Si ita, illas lubenter emerem, simulq. quæ in anglia æri incisæ reperiuntur. Contemplatio imaginum virorum, qui in physica et chemica palæstra desudarunt memet magnopere delectat.

Quanti constat series imperatorum et illustrium Romanorum, more Bentleyano fictorum? Quanti notabiliorum Deorum et Dearum? Nonne catalogus haberi queat cum addito pretio?

Eximia est observatio Domini Fontanæ de Sulphure majore æstu rigescenti sed idem accidit antimonis crudo, argento salito multisq. aliis corporibus.

Huic epistolæ Dissertationem adnecto nuper editam de diversa in metallis phlogisti quantitate. Si plura desideras exemplaria indices numerum.

D. Rinman nuper pigmentum viride invenit, quod tam aqua quam cum oleo non tantum egregium est, sed etiam nulli obnoxium mutationi. En præparationem: Solutio cobalti commiscetur cum Solutione zinci et dein alkali fixo præcipitatio instituitur. Sedementum roseum collectum, lotum, exsiccatum et tandem calcinatum virescit plus minus saturato colore, pro vario ingredientis zinci quantitate.

Actorum Stockholmensium in linguam Germanicam translatorum nuper volumen 35 in lucem prodiit. Vale, vir celeberrime, iterumq. vale. Dabam Upsaliæ, die 22 Dec. 1780.

Amplissimo Clarissimoq. Viro, D.D. F. Schwediauer,
S.P.D. T. Bergman.

Epistolam tuam scriptam, d. 27 Jun., æque ac alium d. 24 Aug. Londini datam accepi. Epistolas tuas in posterum sicut antea inscribas. "To the Royale Society at Upsal," et in meas mox pervenient manus, modo, ut antea, ab initio meum memores nomen. Nec opus est, ut peculiari charta involvantur. Gaudeo, quod mea ultima sarcinula ad te rite parvenerit. A Te ad me missum nondum accepi, nec hactenus de illa Stockholmiæ ullam notitiam adquirere potui. Utinam nomen naucleri vel navis in memoriam Tibi revocare posses, et tempus quo abierit, tum forte, hisce cognitis, melius succedet nova inquisitio. Ut de hisce momentis cito me instruas oro.

Ad finem Augusti gravi afflictus sum morbo. Sanguis, qui per hæmorrhoides per plures annos consuetum habuit exitum, subito corporis superiores partes et præsertim pulmones adgressus est, unde violenta oriebatur hæmoptysis. Parum abfuit, quum hæc in tumulum memet transtulerit. Jam quodammodo restitutus adhuc tamen magna laboro debilitate, adeo ut hac vice plura scribere nequeam. Vale, vir experimentissime, iterumq. vale.

In enumeratione librorum, quos mihi missos scribis, Kirwan de acidorum fortitudine, quam antea promisisti, desidero, sed forte in sarcinula nihilo minus adest, modo illam reperire potem.

Dabam Upsaliæ, d. 12 Oct. 1781.

Celeberrimo D^{no} F. Schwediauer, S.P.D. T. Bergman.

Tandem heri arcam a te misam laetus accepi, simulq. e tua epistola moræ causam, mihi proficuæ, perspexi. Quum autem in litteris, ad finem Junii datis, illam dudum in navi depositam narraveris, inimico fato perditam non potui non credere mense Octobri.

Libri omnes gratissimi fuerunt. Kirvani Schediasma adfuit, quamvis in catalogo missorum ejus fueris oblitus, sed nova methodus Henryana desideratur, hic tamen defectus memet non angit, namq. in opere Cavalliano explicatam spero. Quod imagines ejusdem magnitudinis haberi non potuerint, certo quidem respectu collectionis meæ imperfectionem prodit, sed hoc ipso plerosq. majores ideoq. pulchriores obtinui, sine dubio tamen longe cariores, quod in Te minime redundare debet. Ut igitur quod debeo indices rogo et, præter gratiarum actiones, pecuniam lubenter solvam. In epistola 16 numeras, sed non nisi 15 accepi. Forte Cartesii, qua haberi non potuit, connumerasti. Crystalli arenaceæ gallicæ mihi fuerunt perquam gratæ, æque ac lapidis cyaneo et viridi resplendescentis, nam, quod antea possideo specimen, solum cyaneum colorem monstrat. Alia variatio flavo splendet, sed hanc nondum vidi, forte rariorem.

Crystalli salinæ, quas misisti, nihil aliud sunt, quam Sal Seignetti. Primo intuitu cognoscebam. Auctoris ideo arcanum nihil valet. Pulvis pro poliendo auro est subtilis ochra. Residuum post destillationem nitri cum vitriolo martis solvatur aqua, quantum nimirum fieri potest, hæc solutio filtro coletur, addatur solutio alkali fixi et subtilis decidet ochra, aurifabris sine dubio æque apta, ac missa, forte eadem methodo parata, forte etiam e dicto residuo, motu tantum aquæ, quæ pulverem subtilissimum diutissime suspensum tenet, separata. Color panni lutei missi, ni fallor, modo in § 377 Prælect. Scheffer. descripto, efficitur, potius ochraceus, quam flavus vocandus. In Suecia flores Chærophylli sylvestris (Fl. suec. 257) linteis materiis colorem longe lætiorem impertiunt, qui pluries lotionem cum sapone perfert et lente quoq. solari debilitatur luce. Conferatur specimen heic inclusum.

In quadam epistola dephlogisticationem acidi salis per calcem memoras. Eamdem dein frustra tentavi, nec video qua ratione effici queat. Ut proportiones igitur indices oro, qualitatemq. calcis salitæ: num calx aërata, an vero usta sit solvenda, an residuum post destillationem salis ammoniaci cum calce adhibendum? Dnus. Keir mihi notus est, sed nominas quoq. Keer: num duo diversi chemici? an vero posterius nomen festinante calamo procreatum?

Dnus. Ferber, Prof. Mitaviensis, per aliquot annos a me petiit Regni mineralis Sciagraphiam secundum principia proxima digesti. Talem illi nuper misi manuscriptam, et hac lecta, ut typis divulgare sibi permitterem desideravit et voto ejusdem non potui resistere, quamvis hoc tentamen etiamnum valde sit imperfectum.

Nundinis proximis paschalibus hoc opusculum destinatum credo, quod vix 100 paginas, in octavo impressum, efficiet. In analysi ferri pag. 68, seq. calcem albam a metallo separatum memoravi. Hanc dein ulterius examinavi et, ni fallor, novum indagavi semimetallum, ferro maxime amicum et in illo frigido fragilitatem procreans, cujus causam hactenus multi frustra quæsiverunt. Ceterum hoc metallum a ferro est diversissimum et magnetis imperium omnino recusans. Experimentorum descriptionem Societati Upsaliensi tradidi, ut tomo quarto inserantur. Stannum sulphuratum nuper detexi, cujus in gremio terræ existentiam hucusque omnes ignorarunt mineralogi, sed inter Siberica mineralia, mihi missa examinataq., talem rarissimam inveni mineralisationem. Diu miratus sum, quod hæc desideraretur, nam stannum per artem sulphur facillime suscipit et sulphur in naturæ officina uberrimum occurrit.

Quum Tu omnes cognoscas, qui Londini in Chemiam vel adfinem Philosophiam nat. incumbunt, ut singulorum historiolam pedetentim mihi narres oro. Woulfe, Kirvan, Priestley, Keir, Higgins, Saunders, Crawford, Cavallo, Henry, Bewly, Warltire, Winch, &c. qua nomina et nonnulla opera novi, sed ætatem, munera genium, merita et notabiles vitæ circumstantias ignoro, quæ tamen Historiam litterariam scientiæ, cui me addixi, multum illustrant. Num quidem Pemberton in chemicis scripsit? Citatum vidi. Num ejus imago, quæ in Catal. Bentl. Gallico pag. 67, n. 32, occurrit?

Hanc epistolam scripsi d. 20 Nov., sed per octiduum retinui, tuam responsionem expectans ultimæ meæ præcedenti, jam vero diutius morari nolo. Vale, Vir celeberrime, tuaq. amicitia memet in posterum, sicut huc usq., amplectere.

Quod D. Achard äerem, qui phlogisticatus vocari solet, per nitrum fusum duxerit, illumq. eo ipso connexerit, narras. Methodum certe ignoro, qua hic äer nitri massam transire possit sine admixtione aëris ex ipso nitro orti, qui, uti notum est eximia gaudet puritate, et in hoc casu correctionem efficit. Cerussa sine dubio in Anglia quoq. præparatur, ast peregrinatores, ni fallor, tales fabricas minime memorant.

Dominis Priestley, Kirvan et Hopson meo nomine gratias agas pro missis libris. Qua in posterum Tibi mittuntur multipla ita distribuas oro, ut hi Domini singuli exemplar obtineant. Tractatus Crawfordiani nova editio diu forte morabitur. Quum igitur parvi sit voluminis, ut credo, nonne nitide et accurate describi posset? Impensas lubenter solvam.

Quale est pondus a Priestleyo aliisq. Physicis usurpatum? Quomodo dividitur? Quid significat dwt.? Quando *gallon* simpliciter nominatur, nonne Londinensis pro vino intelligatur? *Winchester gallon* quantum differt?

Dabam Upsaliæ, d. 30 Nov. 1781.

Celeberrimo Dno Schwediauer, S.P.D. T. Bergman.

Sarcinula a Te Edinburgo missa d. 23 Sept. in meas pervenit manus d. 11 Januarii sequentis, adeoq. prius respondere non potui. Frustum terræ ponderosæ aëratæ gratissimum mihi fuit, ut facile Tibi persuadere potes. Donanti ideo Domino Black meo nomine multas persolvas gratias. Quod libri a me missi Londinum appulerint salvi ad finem Septembris, proxime præteriti, per D. Kirvan cognovi: de effigie idem spero, sed ad Te scribere non potui, penitus ignorans ubinam esses, usq. dum adveniret epistola Edinburgi scripta. Marmor metallicum Cronstedtii nihil aliud est, quam Terra ponderosa vitriolata, toto cœlo differens a Lapide ponderosa qui in Mineralogia Cronstedtii inter mineras ferriferas memoratur, § 209, i., edit. suec. Lapis ponderosus est calx acido novo metallico satiata. Est autem adeo rarus hic lapis, ut defectu materiæ non dum metallum, ad quod pertinet acidum, determinare licuerit. Conferas in vol. iii. dissertationem de acidis metallicis.

Ut muria liberetur magnesia calceq. salitis meliorem vilioremq. ignoro methodum, quam quæ in Galliæ quibusdam regionibus adhibetur et in Mem. de l'Ac. 1763 describitur. Scilicet muria collecta in cumulis conicis sub dio accumulatur et culmo tegitur, ne pluvia dissolvat. Interea atmosphæræ humiditas sales deliquescentes devehit.

Calx flava, quam Dr Withering e ferro extraxit, forte nihil est aliud, quam calx Sideri, martiali contaminata, de qua in vol. iii. agitur.

Methodus salis ammoniaci conficiendi a D. Hutton adhibita valde est notabilis.

Pro missis libris, et iis, quos polliceris, gratias ago.

D. a Linné febri biliosa, ter redeunte, lacessitus tandem apoplexia occubuit. Sed hoc sine dubio Tibi dudum innotuit. Quod ad meam attinet valetudinem, hæc certe valde est debilitata. Æstate sub itinere gravem hæmoptyseos accessum passus sum, sed postea vires quodammodo reparata fuerunt, et hæc hiemq. huc usque, ni fallor, minus mihi fuit molesta, quam binæ præcedentes.

In nova elaboranda Oryctologia jam occupatus sum, duobus in 8° comprehenda voluminibus. Num prior hoc anno in lucem prodire queat dubito, ob magnum analysium faciendarum numerum. Regni Senator et Collegii metallici Præses, illustrissimus Comes Bjelke, ut lingua conscribatur suecana petiit, uberiorem inde in nostros monticolas redundaturum fructum exspectans. Methodum ex commentatione de systemate fossilium naturali, quam misi, cognoscere potes. In novellis litteratiis alicubi legi Priestleyum in Americam abituram, ni fallor, vel in Siberiam. Num verum?

Experimenta aërostatica in Anglia incepta novi. Describas mihi adcurate methodum, qua globos aëre inflammabilo implent? Quo medio hunc aërem procreant? Quomodo sub itinere hujus aëris volumen augent, si altius surgere volunt? Cetera. Vale, Amice æstimatissime, et memet inter tuos numera amicos.

Dabam, die 13 Jan. 1784.

Notice of the Vendace of Derwentwater, Cumberland. In a Letter addressed to Sir William Jardine, Bart., F.R.S.E.

By JOHN DAVY, M.D., F.R.S., Lond. and Edin.

MY DEAR SIR,—I have carefully compared the vendace from Lochmaben, which you have been so good as to send me, with the one I have which was taken in Derwentwater, and the result is, that they are in every respect so alike, that no doubt can be entertained, I think, of their being of the same species. I have shown them to my friend Sir John Richardson, and he is equally convinced of their identity.

You remark that this fish, the vendace, is quoted as an instance of "local distribution;" adding, "it is right that its range should be corrected," and you express the opinion that it is "more extended." As the distribution of species has now become a subject of more than ordinary interest to the philosophical zoologist, it may not be amiss, perhaps, to enter into some particulars relative to the vendace, as showing, in accordance with the opinion you have expressed, that its habitat is not so limited and isolated as was long the current belief.

By my friend Dr Lietch of Derwent Bank, Keswick, to whom I am indebted for the specimen of the fish from Derwentwater, I have been informed that its existence in that lake has been for many years past known to the boatmen; and an old fisherman, one of those boatmen, has assured me that it is not only well known, but known to be pretty common there. He stated, that about eight years ago, many were taken, towards the upper parts of the lake, at Lodore, at one draught of a net; that he himself once took one with the artificial fly, and that he knew of another having been taken in angling with a worm. The specimen in my possession, I was told, was one of two killed accidentally by a stroke of an oar.

From the same informants I learnt that this fish occurs in Bassenthwaite Lake—a lake which is separated from Derwentwater only by about three miles of river (the Derwent), of gentle flow,—in its whole course of about three miles, without any obstructing fall or rapid; and, in short, the fish is about as common in the one lake as in the other. In confirmation, it was mentioned that, not long ago, no less than sixteen or eighteen were captured there at one cast of a net. A specimen from Bassenthwaite is preserved in the Museum at Keswick, and, from such an inspection as I have made of it, I believe it to differ nowise from the vendace of the adjoining lake.

Whether the vendace exists or not in any other lakes of the lake district I am not prepared to say. Such inquiries as I have made after it on visiting the larger lakes, have hitherto been un-successful. The most likely places to discover it are the secluded mountain tarns, in which a net is seldom if ever cast.

You are aware that in two of the lakes of the district, and in one of its tarns, viz., Ullswater and Hawes Water, and Red Tarn, a fish certainly of the same family occurs, and is plentiful. The Coregonus of Hawes Water I have examined: I was present at the capture of a specimen taken with the artificial fly—an uncommon incident. It appears to be the same as the schelly, figured and described by the late Mr Yarrell in his "History of British Fishes," and supposed by him to be identical as to species with Gwyniad of Bla Lake in Wales. The Coregoni of Ullswater and of Red Tarn, are commonly spoken of by the country people as fish of the like kind, under the name of the fresh-water herring, or schelly; but that they are truly identical species, I cannot even offer an opinion, never having examined a specimen of either, and not being aware that they have hitherto been examined with sufficient care by any competent observer.

Recurring to the speculative subject—the distribution of species—one naturally casts about for a way to account, not for the isolation of the fish under consideration, but for their diffusion, moderate as that is, according to what is known of their localities at present. Of the many conjectures that may be offered, one, and the most obvious, is, that they were intentionally conveyed by man from their original locality; another, that they were accidentally carried from place to place by an aquatic animal, such as a water-ousel or an otter; a third, that they might have been transferred by means of a moving body of ice, a glacier, or by a water spout; a fourth, that they might have found their way by the sea.

The first mode of conveyance—that by man—seems plausible enough in this instance of the vendace, especially since the attempt made with the impregnated ova of the fish, the distance between the lakes of Lochmaben and those of Cumberland being so inconsiderable; but this same method hardly comes within the bounds of probability in the instance of the schelly of Red Tarn, that tarn being one of the least accessible of our mountain tarns, and the fish itself one of the most difficult to capture. Of the other suggested ways, the third and fourth seem the least probable, and the last hardly even possible. First, in the instance of the fish of Red Tarn, considering the situation of that tarn on the flank of Helvellyn, and only three or four hundred feet below its summit; next, in that of the vendace of Derwentwater and Bassenthwaite, keeping in mind that there are falls and rapids in the river in its course from the latter lake to the sea, such as it is difficult to suppose surmountable by so feeble a fish as the one in question. It is worthy of remark, however, that the vendace has been taken alive in the tideway of the Solway—an emigrant no doubt from one of the lakes of Lochmaben. The fish, I believe, is known to you; I have been assured of it by Sir John Richardson, by whom the specimen then taken was deposited in the Haslar Museum, and afterwards transferred to the British Museum. The second mode, —that of accidental conveyance by an aquatic animal,—seems to be least open to objection. In a paper published in the Philosophical Transactions for last year, and in another to be found in the Proceedings of the Royal Society for the present, I have related experiments proving that the impregnated ova of the salmon may be kept many days exposed to the atmosphere, when the air is saturated with moisture, without their losing their vitality; that under the same circumstances, when packed in moist moss or moistened wool, they may be conveyed many hundred miles with a like result, and be afterwards hatched; and also, that their vitality is not destroyed by their coming in contact with and adhering to ice, their temperature at the same time being reduced to the freezing point of water. Are not these facts applicable by analogy to the ova of the schelly and vendace? And if so, are they not capable of affording some explanation of these fish in common with so many others, especially the trout, being found in waters so situated as to render it extremely improbable that they could have been introduced where found, excepting in this accidental way?—I am, &c.

JOHN DAVY.

LESKETH HOW, AMBLESIDE,
November 8, 1856.

Note to Dr Davy's Paper on the Vendace of Derwentwater.
By Sir W. JARDINE, Bart.

From the foregoing observations, it will be seen that the vendace is no longer to be considered as confined to the Lochmaben lochs. These have long been taken as the only locality for it, and, like that of the supposed restricted locality of the British red grouse, has formed the basis for argument and theory on the distribution of species. Some years since, by the attention of Mr Davies, now assistant to Professor Allman in the University of Edinburgh, I received a drawing from the English lake district of a fish which appeared very similar to that from Lochmaben, but on which alone it was unsafe to decide without the examination of specimens. Dr Davy has, however, now removed that doubt, and the locality remains no longer restricted. The specimen taken in Derwentwater has been obligingly sent for comparison; when placed beside a Lochmaben fish of equal size, the general form appears stronger or stouter, the proportions of the parts larger; but I cannot mark anything that would entitle it to specific distinction. Since the MS. of Dr Davy's observations came into my possession, I have also received from T. C. Eyton, Esq., specimens of a fish from Bala Lake in Wales. These Mr Eyton compared with specimens of vendace from Lochmaben, and I have now done the same. There are slight differences in the opercular outline; not more, however, than would occur in specimens from the same lake. Mr Eyton thinks the Welsh fish identical, and I cannot perceive any differences of sufficient value to place them as distinct. Thus it is that the distribution in this country appears to have a considerable range; and it remains yet to be seen whether the British fish are not also the same with one of the continental species. When Professor Agassiz visited this country in 1834, specimens of the Lochmaben vendace were shown to him. He thought it distinct from the species known on the continent as the *Coregonus marænula.* At that time he expressed no doubt, and on this account the Lochmaben fish was named in honour of the great British ichthyologist Willoughby. I have never been able to make the comparison between British and continental specimens, but, except from the statements of Agassiz while in this country, there is no authority from direct comparison for stating that it is distinct. My impression is, that it will prove not to be so, and that the range will therefore extend to the lakes of the continent.

Dr Davy mentions one instance of the vendace being taken in the English lakes with the artificial fly. I do not doubt this, as the habits of the fish may differ from the abundance or scarcity of entomostracan food in the waters it inhabits; but the form of the whole mouth,—the small weak teeth,—the elongation and structure of the gill appendages, all show an apparatus for taking that peculiar food with which we have always found the stomach of the Lochmaben fish crammed. Dr Baird, of the British Museum, so well known for his researches among the entomostraca, examined the Lochmaben fish last summer by the water side, with the view of determining the species of entomostraca taken as food, and found nothing but these small animals in the stomach. The stomach of the Bala fish was also sent to him, but this presented very different contents,—the debris of water insects and their larvæ, and the remains of some dipterous insects; but only one specimen of entomostraca (Daphnia) could be found. The stomach of the Derwentwater fish was entirely empty of all food.

Thus it appears that the different localities afford different food, and in those where entomostraca are scarce, other support must be collected, and an artificial bait will occasionally be taken.

Entomology of the Vicinity of Melbourne, Australia. Communicated in a Letter to Mr Jones, Worcester. By Mr P. Edwards.

I now come to our favourite order Coleoptera; and were I to say all that I ought to say about the many beautiful species to be found in this country, I should tire your patience, and fill more sheets than I have time to write. I shall, therefore, briefly glance at the principal families, noticing more particularly any remarkable species, and leave you to form your own judgment from some specimens which I will shortly send to you. We appear to have several families which have no representatives at home, but with most of them I am familiar, and I will endeavour to give you some idea of what my collection of Coleoptera is composed.

First, then, the Adephaga are by no means so numerous as at home, and are chiefly confined to the Lebiidæ and Harpalidæ. Of the Cicindelidæ I have seen no example; and in a collection belonging to Mr Robert Bakewell, containing upwards of a thousand species of Coleoptera, this family was wanting. The Lebiidæ are perhaps more numerous than any of their tribe, and are found chiefly under the bark of the gum trees. Many of the species are very prettily marked with the colours of tortoise-shell; they are mostly small insects, rarely larger than from 2½ to 3½ lines. One species, which I met with under burnt logs on the Plenty Ranges, has remarkably flabellate antennæ; elytra rich chestnut brown, faintly striate; thorax cylindrical. This insect has been described, I believe, by Mr Hope, but I am ignorant of its name. The Scaritidæ give me three species, one of which is about 8 lines in length; the other two appear to be of the genus Clivina. My Carabidæ are very few also, and principally small species, like those of Helobia and Leistus at home, though some most beautiful examples of Calosoma have been taken here. The Harpalidæ are by far the most numerous of the Geodephaga, though, as I have said, by no means so common as at home. I possess a few very fine species; the largest is a species of *Catadromus* about 1 in. 3 lines in length, deep black, with punctate striate elytra—the striæ very distinctly marked; and with a broad margin of brilliant golden-green, which fades slightly after death. This insect is found under stones in the winter, and, upon being taken in the hand, exudes a yellow acrid fluid, which, once coming in contact with one of my eyes, caused me very considerable pain. Other Harpalidæ are mostly black or brassy green, like the genera Harpalus and Agonum. Of the Bembidiidæ, the genus Lopha, or one very similar to it, appears to be far from rare, and I have found many small insects like Bembidium; but this tribe requires more studious investigation than I have been able to give to it. In the Elaphridæ we are poor. Two small species, about 1½ lines in length, which are both found on flowers of Composite, are all I am acquainted with. The flowers on which I have met with these beetles were covered with myriads of very minute Aphides, and probably they formed the objects of which the Elaphri were in search. Among the Hydradephaga, two species of Colymbetes are most abundant in all our waters, and in the evenings of summer are found on the wing in almost incalculable numbers. Hydroporus, too, has its examples; but Dyticus I have not seen. Gyrinidæ are most plentiful in the Creek, one species being extremely like the Gyrinus natator of England. We have one, however, with the posterior half of the elytra light chestnut-red, the remainder black. This is not common. The Helophoridæ are not frequent, only about four small species being known to me. The aquatic insects of the colony would well repay investigation, as I am sure many more than those we are acquainted with must remain unknown. The Sphæridiidæ present us with some small species, principally found on flowers, and under the bark of the Eucalypti. The Necrophaga are by no means numerous; and, indeed, the offices which they perform in the economy of nature appear to belong to the lot of the ants and flies. I have seen and taken, however, one species of Necrodes, with high broken ridges on the elytra (*N. lacrymosa*); a genus of small insects of the Nitidulidæ, with the elytra only covering half the abdomen; three Silphæ under bark of gum-tree; a few small Mycetophagidæ; two Engidæ in the bole of a tree; and three Dermestidæ, besides a small species which I took a few days ago, and which may turn out to be an Anthrenus. Most of these have been found in situations entirely different from their habitats in England, having been principally met with underneath bark, and among decayed wood; but with one exception, none have been seen by me in carcasses, though I make a rule to turn over every dead opossum or native cat I meet with. The Byrrhidæ I do not know here. Of Histeridæ I have one species, bright golden or purplish-green (*Saprinus laetus*, Erichs); very common in carcasses and decayed vegetable matter. It is about 2½ lines in length. Of the Pectinicorns, one of the most beautiful is the well-known *Lamprima ænea*, which is found in immense numbers in the dry months of our summer. It is of the most brilliant golden green, sometimes bluish or purple, with very large mandibles (smaller in the female); it feeds upon the wattle trees (Acacia), whole groves of which it sometimes destroys in the course of a season. We are far from deficient in the Lamellicorns. Onthophagus presents us with four species, mostly ash-coloured, with dark markings, very similar to those well known to you at home; and I think five or six Geotrupidæ may be named. Six of the Aphodiidæ are all I have seen. The Melolonthidæ are very numerous,—two large and brilliant species positively swarming upon gum trees in the early part of the spring. The small genera, like Phyllopertha and Hoplia, are abundant on young shoots; and a few species are also found on the flowers of different shrubs. Of the Cetoniadæ we have some: one genus (Schizorhina) is extremely abundant on the flowers of the native box (*Bursaria spinosa*). The *S. punctata* is about six lines in length, with gold-yellow elytra, irregularly marked with black spots; the pale testaceous appearance it bears in collections in Britain gives no idea of its beauty; and the *S. australasiæ* is still more remarkable for its colours. The elytra are rich brown, with waved bands of black and bright canary-yellow. Both these insects I have positively seen this season in thousands. The *Diaphonia Hookeri* is a handsome species, about ten or twelve lines in length; elytra pale chestnut-brown, inclining to testaceous, with a broad black band extending down the thorax and along the sides of the suture. This is found upon the acacia, though it does not appear very common.

To give you some idea of the numbers in which some species are found, I must tell you that upon a single tree, in one morning, I took upwards of 200 specimens. After our hot winds, which, unfortunately for the health of the colony, are too prevalent in the summer, the Longicornes are seen in great quantities, and frequently fly into our houses at night by the open windows. The different species of Eucalypti are their special home, and sad havoc they make among some of the trees. They are principally Cerambycidæ; though of the Lepturidæ I have taken six or eight examples. In many of the former family the antennæ are twice the length of the body. The Crioceridæ have two beautiful species found on the acacias in spring, one of which is vermilion-red with black spots, and the other orange with black spots and a black thorax. These are far from frequent. I have seen no Donaciæ, though I have searched well for them upon the aquatic plants in our locality. The Cyclica are very numerous, particularly the Galerucidæ and Chrysomelidæ, both of which families exist in profusion upon the gum trees, and present an almost endless number of forms, many of which are very striking in the disparities of their colours. We have several Halticæ—one species very similar to the *H. nemorum*; but none, as far as I have been able to learn, so destructive in habits as that well-known insect. The genus Cryptocephalus is very abundant in species, several of which have very brilliant colours. I know two species of Cassidæ, both found on Eucalypti. Of the Coccinellidæ, I know one Chilocorus and five Coccinellæ, all of which are found on acaciæ. Our Tenebrionidæ are principally found under bark; one species is very large, being about ten to eleven lines. Of the Blapsidæ we have two species, Cistelidæ five, and Lagria, so like *L. hirta*, that I cannot distinguish any difference. Several large and beautiful Mordellæ occur on flowers—one Rhipiphorus on gum trees; and a large and beautiful beetle, with pectinated antennæ, which I have taken on the Plenty Ranges, belongs apparently to the genus Trigonodera. The genus Anthicus is abundant; and one species of Noxoxus occurs. The Brachelytra are comparatively few, and not very different in general appearance from our common species at home. I only possess about twelve species.

This ends my list of Coleoptera, and I therefore pass on briefly to mention the remaining orders. The Orthoptera are very numerous, and number among them some very singular insects. Among the more remarkable are the Phasmidæ, or walking-stick insects, as they are familiarly called. These curious creatures are found upon gum trees in abundance in some parts of the bush. They are often four or five inches in length, though the body of most of them is seldom thicker than a straw. We have several of the genus Mantis, which are also very curious insects. I have taken one Gryllus, with much the same habits as the *Gryllotalpa vulgaris* of Britain. The Locustidæ and Achetidæ are very numerous indeed, particularly during the driest part of our summer, furnishing an abundant supply of food to the bush turkey (*Alectura Lathami*, Gray) and somei of our plovers. I have collected nearly 100 species of the Hemiptera, many of which are large and handsome. The Eucalypti furnish them in abundance, as well as the next order, Homoptera, of which the most remarkable insect is a very large Cicada, which exists in such numbers in this locality, and creates such a tremendous noise, as to be a complete pest. Its clear membranaceous wings, when expanded, are almost four inches in width; the head is very broad, eyes red, disk prominent. On a hot summer day these insects are so abundant, and so incessant is their chirping, if it may be so called, that you are almost bewildered with the sound. Several curious insects, allied, I think, to Centrotus, are found upon the wattle trees. They are remarkable for having singular protuberances from the thorax. The Neuroptera are plentiful in the neighbourhood of streams; and many of our dragonflies are large and brilliant in colour. I have seen two or three of the ant-lions (Myrmeleonidæ) on the Plenty Ranges, and I have also taken specimens of the genus Ascalaphus belonging to the same group, which are very peculiar, in having long filiform antennæ, terminated by a knob like that of the diurnal Lepidoptera. One genus, with black and yellow wings, allied to Panorpa, is found on the trunks of gum trees in the autumn. I know two species of Termes, and a species of Hemerobius, very like *Chrysopa perla*, is occasionally found in gardens, &c. The caddis-flies are numerous in the Merin Creek; and one species I have remarked to have antennæ nearly three times its own length. Hymenoptera are most abundant on flowers, &c. My collection numbers 180 species. Ichneumons are very numerous, and some of them with ovipositors of an immense length. As to the ants, they are one of the greatest nuisances of the colony, not a single place being free from them. If you walk in the bush, they crawl up your legs, and soon remind you of their presence; in the house they devour sugar, meat, flour, butter, and in fact anything which is consumable. But what annoyed me much more than this, was the fact of their attacking my Lepidoptera, and devouring many beautiful species, just leaving me the pins. In the bush there are incredible numbers; and a few of the species raise enormous mounds, from which a path, perfectly free from all impediments, and cleared of all the grass, generally conducts to the nearest gum tree. Some of the nests formed by the wasps are very beautiful, and are often found attached to branches of shrubs. The honey-bee (*Apis mellifica*) has been introduced here, and thrives admirably. I now come to the Lepidoptera, which are not nearly so abundant as I expected to find them. The butterflies are particularly few, only nineteen species being known to me. One of them, and the most common, is closely allied to the *Cynthia cardui*. We have two or three Polyomati, and a beautiful Thecla, with pale metallic-blue wings, edged with a broad black band. The underside of this insect is buff, with irregular markings of orange and black. A small copper butterfly is common on the grass plains, and we have two or three species of Hipparchia. Of the Sphingidæ, I know but three species, and two or three resemble the genus Ino, and are found in the same situations. A large and beautiful Smerinthus is the remaining species. I should have mentioned that four skippers are found in one neighbourhood. We are richer in the moths, and possess many which are remarkable for form and beauty of colouring; but the smaller species, such as the Tortricidæ and the Yponomeutidæ are the gems of our Australian Lepidoptera. I have paid a good deal of attention to them, and number nearly 200 species of these two families. Of the Diptera we are furnished with a superabundant supply, and particularly of the *Musca domestica*, which exists here in such numbers as to be a complete plague. Even while I write, they are all over my face, and making most persevering efforts to get into the corners of my eyes. It is useless to try to avoid them, for go where you will, there are the flies also; and, after slapping your face and rubbing your eyes until you are a fright, you feel like Keeley in one of his farces, "almost tempted to say—damn;" but you dare not do so, for if you but open your mouth, down pop half-a-dozen resolute flies, and you are bound to cough for an

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hour to get rid of them. The only way to avoid this terrible annoyance is to wear a veil; thank goodness, the fires and frost kill them. Among the rest of our Diptera, we have some large and bright-coloured species; and one singular black and white fellow is distinctly marked with a skull and cross-bones. I have seen two or three of the Bombylii, but they are by no means numerous. Tabanidæ are common in exposed situations; and I have taken two or three singular species parasitic upon birds. These latter are, I think, of the genus Oxypterum.

An Account of an unusual Thunder-Storm, and of a Destructive Local Flood. Contained in extracts of Letters addressed to Dr John Davy, F.R.S. By Mr WILLIAM PEARSON of Windermere.

On Tuesday, 9th Sept., we had here almost continuous thunder all the afternoon. But about 6 P.M. there occurred a sudden tremendous burst; it seemed right over the house—the flash and report simultaneous. If a heavy cannon, a thirty-two pounder—had been fired on the roof, it could not have been louder, nor I think so loud. We had, however, no damage done except a square of glass cracked in the dining-room.

But the farmer, on fetching up the cows from the meadow below the house, noticed tufts of grass and sods scattered on the ground not far from the hedge. They had come from the dyke on which it grows, at the foot of a large ash tree, some of the roots of which were laid bare and the bark peeled off; the hazels in the hedge stript of their leaves, and a kind of opening made. The sods, with fern roots attached, had been driven on each side of the hedge, in nearly a straight line, to the distance of 15 or 20 feet. I think there can be no doubt that the electric force came from the ground, for if it had descended from the clouds, would not the tree have shown some signs of it? but there was not a leaf or branch disturbed, though hanging right over the dyke from whence the sods, &c., had been ejected. These appearances were not observed before the thunder-storm, and, no doubt, were caused by it—probably by that tremendous crack.

Several years ago I witnessed here effects somewhat similar from a thunder-storm. A holly tree, on a rough pasture, had been struck—the root bared from soil, and some of it thrown up among the leaves. But what was curious, the electric matter had diverged from the tree to almost every point of the compass, like the spokes of a wheel, ripping up and slightly guttering the earth, as if caused by the plough. A few yards from the tree on one side was a stone wall—one of those spokes or divergent forces had encountered it—had passed beneath it, under the foundation-stone, and come out at the other side, where was growing a crop of potatoes; it had cut through five or six of the rows or stitches as cleverly as if it had been a plough!

The question the meteorologist has to solve is, How a fall of rain—that is, small globules of water—could so suddenly produce a volume of that element, of such weight and force as to cause the effects described.

You would doubtless read in the newspapers at the time a note of a very heavy fall of water, attended by thunder, that occurred at Borough Bridge, on the Lune, on the 8th of August 1855, if I remember correctly. About a week after, I visited the place, accompanied by a friend, on a journey we made to some of the eastern parts of the county. There was something so tremendous in the havoc this storm had occasioned, that I am sure you will excuse me if I endeavour to describe some of the most prominent effects we witnessed. At Cragrigg Hawse we first came in sight of the Lune valley. Carnigill, east of the Lune, a mountain with a smooth green surface, is right opposite; but it was now (contrary to what I remembered) furrowed with several red streaks or gutters, caused by the sudden and heavy rush of water down its smooth declivity. In the stone wall at its foot there was a large gap, 20 or 30 yards in width at least, which had been made by the impetuous flood, and in the field below an immense mass of earth and stones, covering about an acre of it. The road from the Hawse to the inn is a long descent. There is a new stone wall on the right of the road, on the other side of which the mountain rises pretty steeply. This wall, in one or two places, was washed down, and the road covered in parts with soil, stones, and gravel; in one place a complete landslip had occurred—a part of the mountain side, with the green sod at the top, had slid across the turnpike, so as to prevent the passage of carriages till a part of it was removed. On reaching the inn, we were told the flood had entered the house. We saw that, in running down the lane below, it had worked itself a channel of about two feet deep. But the greatest havoc was east of the Lune. After crossing the bridge, we went up the lane that leads to a farm-house just under Carnigill. It was rendered quite impassable for carts—a channel of from two to three feet deep being cut in the middle of the road. But what shows more convincingly than anything I have mentioned the immense mass of water thus suddenly precipitated, was, that the branches of the hedge on our left, through which the water had passed into the lane, were covered with pieces of grass and wreck to the height of at least three feet! And, recollect, that this body of water had flowed down the smooth slope of a mountain, and not been absorbed by the ghylls, as would have been the case in a common heavy thunder-shower. It seems to me that if the contents of one of our small lakes (Esthwaite Water for instance), could have been carried to the summit of Carnigill, and then suddenly let fall, it would not have produced a heavier or more overwhelming flood. Mr Day, the landlord at Borough Bridge, told us that this shower (it was a shower in the valley below, with loud thunder) did not cover an area of much more than a mile in diameter. Is it not extraordinarily odd that this huge mass of aqueous vapour should reach the top of Carnigill before it met with a body of cold air to change it into water?

PROCEEDINGS OF SOCIETIES.

American Association for the Advancement of Science.

Tenth Meeting. Albany, August, 20–27, 1856.

(Continued from p. 198.)

Whirlwind and Tornado Vortices. By W. C. Redfield.—A special rotation constitutes the essential portion of these remarkable movements in the atmosphere. As regards the interior and the more exterior portions of the whirling body, the course of the spiral rotation, whether to the left or the right, continues one and the same. But the oblique inclination which the spiral movement also has to the plane of the horizon, in these two portions of the vortex, is found to be in opposite directions. Thus, in the outward portion of the whirlwind the tendency is downward, when the axis is vertical; but in its interior portion the spiral inclination or tendency is *upward.* This fact explains the ascensional effects in tornadoes, and in more diminutive whirlwinds. Owing to the greater density of the air at the earth's surface, the normal course of the gradually descending movement, in a symmetric whirlwind, is that of a closing spiral; while the course of the ascending movement in the interior portion of the body is that of an opening spiral.

In the aerial vortex, the area of the ascending movement, or spirality, is by far the smallest portion of the body; for the reason that its rotation is proportionally more active and intense, being produced by the great weight and momentum of the surrounding body, converging by an increasingly rapid motion into a smaller area.

In aqueous vortices, the spiral inclination of the interior and exterior portions is reversed, the descending spiral being nearest the axis of the vortex. Hence, lighter bodies, and even bubbles of air, are often forced downward in the water in the manner in which heavier bodies are forced upward in the aerial vortex.

So-called Human Petrifactions. By Trail Green.—Descriptions of petrifactions of human bodies which occur in the newspapers appear to refer to the conversion of bodies into adipocere, and not into stone. All the supposed cases of petrifaction are probably of this nature. The change occurs only when the coffin becomes filled with water. The body, converted into adipocere, floats on the water. The supposed cases of changes of position in the grave, bursting open the coffin lids, turning over, crossing of limbs, &c., formerly attributed to the coming to life of persons buried who were not dead, is now ascertained to be due to the same cause. The chemical change into adipocere, and the evolution of gases, produce these movements of dead bodies.

II. SECTION OF GEOLOGY, NATURAL HISTORY, AND ETHNOLOGY.

On the Volcanic Phenomena of Kilanea and Mauna Loa; and on the Dynamical Theories of Earthquakes, &c. By C. F. Winslow.—Referring to the phenomena of the eruption of Manua Loa in August 1855, and to numerous facts observed by him in Hawaii, and by other observers there and in other parts of the globe, the author maintained the general theory that volcanic and earthquake actions are due to powerful movements in the molten matter beneath the thin crust of the earth. He attempted to show that they were more frequent in winter than in summer, and thence concluded that they were due to the force created by the sun on the molten interior of the globe, which being greatest in winter when the sun is nearest the earth, would at that time occasion an increased pressure of the liquid against the superincumbent crust.

Exhibition of Living Gar-pikes. By J. E. Gavit.—Professor Agassiz said that the apparition of the oldest-fashioned fish alive was hardly less striking than if one of the old Egyptians were suddenly to present himself in the hall. There were very few types of this kind to be found among living fishes, but there were many among fossils. They had what other fishes had not, a ball-and-socket joint in the neck, so that they could bow; this was common to them with reptiles. Their pectoral fins were small, and continually in a vibratory motion like the cilia of animalcules. The same motion was also observed in the upper lobe of the caudal fin, which was the actual prolongation of the back-bone, and analogous to the tails of reptiles. In the Old Red Sandstone he had found a fish which he called Glypticus, with the same sort of tail. This went, with so many other things, to show that the order of succession in past times was exemplified now in the development of individuals. Here were also two features observed in genuine reptiles, the power of moving the head on the back-bone, and the *quasi* tail. He had noticed, also, that these fishes would rise to the surface of the water, draw in air at the nostrils, and then emit bubbles from his gills. This was singular, and was a character only known to exist among reptiles.

Notes on the Geology of Middle and Southern Alabama. By A. Winchell.—This was a somewhat detailed account of the geology of those parts of the State examined by the author, and was illustrated by a map comprising the country, from the Tertiary near the junction of the Tombigbee and Alabama rivers, north along their courses, half way up the State, exhibiting a complete range of strata to the Silurian. The map was also accompanied by some valuable sections, by specimens of the rocks, and by a very large collection of Tertiary fossils, principally Eocene.

Parallelism of Rock Formations in Nova Scotia, with those of other parts of America. By J. W. Dawson, A.M.—In this communication Professor Dawson sketched the chief features of the geology of Nova Scotia, from the submerged forests, and Boulder Clay and Drift, to the

Silurian rocks, dwelling more particularly on the Carboniferous system so largely developed in that region. He spoke of the gypsiferous Limestone formation, or lower Carboniferous group, as gradually running out in a certain direction, and giving place to Conglomerate. Just as the Carboniferous Limestone tract of the Appalachian was known to disappear, and give place to coarse sedimentary rocks in approaching that chain; and he referred to the gypsum deposits, and the Coal-measures below the Limestone, as features peculiar to this north-eastern region, which were not recognised in the Appalachian belt. He exhibited specimens of rain-marks and foot-prints, as well as of stigmaria and other characteristics of the coal measures.

Professor W. B. ROGERS remarked that the parallelism of formations in Nova Scotia and the United States was much closer in some respects than had been represented. The Limestone beneath the great Coal series (Carboniferous Limestone), instead of being wanting in the Appalachian belt, as stated by Professor Dawson, was present, throughout a great part of it, in much greater force even than in the far west. Along the south-eastern margin of the chain in Pennsylvania, it is represented by a vast thickness of red and variegated shales and sandstones, which, in approaching the Potomac River, is parted into an upper and lower mass by the intercalation of a wedge of Limestone, which, expanding towards the south-west, attains, in the vicinity of New River, in Virginia, a thickness of more than a thousand feet. Here it is found to include a very thick deposit of gypsum associated with rock-salt. Below this group of shales and limestone, there may be traced, for many hundreds of miles, a thick mass of grayish sandstones, shales, and pebbly rock, containing coal-plants, and, towards the south and west, including one or more seams of coal. This group of beds, designated as the Vesperteni series, is of sufficient thickness to form in general a distinct ridge or crest. Thus, in the Appalachians, we are presented with the Carboniferous Limestone and gypsiferous rocks, and the subjacent oldest Coal-measures not less distinct, and on even a larger scale than in Nova Scotia.

On Carboniferous Reptiles. By JEFFRIES WYMAN. — Professor Wyman remarked, that as we descend in the series of deposits the remains of such fossils become fewer downward to the Coal formation. In America the remains of reptiles in the coal series are found by their footprints. Some have been discovered by Lea, and others are to be described by Rogers—but these are of the Batrachian order. Now, it is necessary that great caution be used in deciding upon the character of animals thus made known to us, since they sometimes exhibit both reptilian and ichthyic characteristics. The Gar-pike, for instance, described by Professor Agassiz, might be taken for a reptile if only a part of its skeleton was found, and *vice versa.* One part of a vertebra would lead the anatomist to judge it a fish, another part would give equal reason to suppose it a reptile. We must therefore have many parts of a skeleton. The fossil which was now under discussion was forwarded by Dr Newberry, from the coal of Ohio, and was undoubtedly a reptile. The cranium is so much like that of a frog as to give the impression, upon first inspection, that it is that animal; but on counting the vertebræ, we find the number to be too great. The skull is that of a tailless batrachian; the posterior parts, those of one with a tail. He was sure it was not a fish; it looks like a serpent. There are in these remains two characters not found in existing reptiles: First, broad processes in the vertebræ, comparable to the *Menapoma* of the western rivers, and thus far the animal was batrachian; Secondly, ribs like those of a serpent, unlike any known batrachian. Of existing batrachians, some are without limbs, and some with limbs. Some of these latter have two toes; some three, and others four and five. The footprints found in Pennsylvania exhibit five toes before and four behind. In this specimen appearances indicate the existence of a fifth toe on the forefoot, which may yet lead to the discovery of the connection of these footprints with batrachian reptiles.

Professor Agassiz said that this was very welcome evidence of reptile life, and the difficulty of identifying animals from mere portions of them. He said that in the dissection of turtles he had discovered the bones in the turtle's neck which were supposed to be peculiar to birds, so that had a skeleton been found, the upper portion of it would have been referred to a bird, and the lower to a reptile. These discoveries forced upon science the necessity of reconsidering many cases which were now relied upon as furnishing good evidence of the existence of peculiar animals in past ages. He believed that the batrachians did not belong to the class of reptiles, but that they formed a class of amphibians intermediate between reptiles and fishes, and comprising a large portion of what were called the large reptiles of the old ages.

Proof of the Protozoic Age of some of the altered rocks of Eastern Massachusetts, from fossils recently discovered. By W. B. Rogers.—The substance of this paper has already appeared in the September No. of this Journal.

On the Geological Position of the Fossil Elephant of North America. By J. W. Foster. This was an elaborate paper comprising a variety of local details. The following is the author's summary.

From all the facts, I am disposed to believe that the fossil elephant commenced his existence before the drift agencies had entirely ceased—when the water stood at a higher level—when the contour of the continent was different—when a different climate prevailed, and when a subarctic vegetation stretched far towards the tropics—at a time when the valleys were excavated by the returning waters, and the streams assumed nearly their present direction. It was a period of erosion, which ought to be marked by distinct geological monuments. I would designate it as the Fluviatile Period. Although, in rare instances, the remains of the elephant and the mastodon are found side by side, there are deposits apparently newer, which contain the mastodon, and in which those of the elephant have never been found. The inference, therefore, might be drawn that, although at one time contemporary, the one was introduced earlier, while the other survived later. Contemporary with these fossil pachyderms was the fossil beaver (*Castor oides*). In bulk he was twice the size of the existing species, and was adapted to a wide geographical range. Contemporary too with these pachyderms was the mastodon (*M. giganteus*,) of a more ponderous frame, but of an inferior weight. The fossil beaver tenanted the streams and lakes. Herds of cattle (*Bos* *bombifrons* and *Bison latifrons*) roamed over the plains, while the tapir wallowed in the swamps. In the milder regions of the south, visited by the elephant and the mastodon in their migrations, lived the great leaf-eating megatherium, the mylodon, megalonyx, the hippopotamus, the horse, the elk, and the deer, all belonging to extinct species, while at the head of the carnivora stood the colossal lion (*Felis atrox*), which then, as now, was the monarch of the forest.

On Some Points in the Geology of the Upper Mississippi Valley. By Professor JAMES HALL.—Professor Hall exhibited a map of the Middle and Western States, which was the first attempt made by him in 1841 to represent the geological formations of the east, and their prolongation in the west. At that time he was led into some errors, which subsequent investigators have set right. The Cliff Limestone of Owen and the western geologists embraces strata belonging to the Lower Silurian, the Upper Silurian, and the Upper Helderberg groups, as is now known. One of the difficulties in the way of identifying the western formations in the eastern was the supposed absence of the Hudson River group at the west. In 1850, in company with Mr Whitney, he traced this group around the north sides of Lake Huron and Lake Michigan to Pointe aux Baies, and thence along the eastern shore of Green Bay to Lake Winnebago. The washing away of the softer shales of the Hudson River group has given Green Bay its present configuration. This group should make its appearance on the Mississippi if continuous in a western direction, but up to the last year it had not been recognised in that region. In the autumn of 1855, however, he had, in company with Mr Whitney, while engaged in the Iowa survey, examined several localities where shales may be observed lying between the Galena or lead-bearing limestone, the upper member of the Trenton group, and the Niagara limestone. These shales are filled with organic remains of the age of the Hudson River group of New York, and thus furnish evidence that the sequence of the rocks, as observed in this State is the same, or nearly the same, in this part of the Mississippi Valley. The "mounds" of Iowa and Wisconsin are made up in part of these shales, overlaid by the harder beds of the Niagara limestone, and a fine section of nearly the whole series may be obtained at Scale's Mound, near Galena. Owing to the soft and easily decomposing nature of these beds, they are usually covered by soil and vegetation, but the peculiar shape of the mounds, as well as other circumstances, would lead to the conclusion that such beds as these would be found in them. He had also ascertained that the Onondago Salt Group existed with a thickness of 100 feet on the Mississippi, distinguished by the same lithological character as in New York. A thick bed of limestone, above the Niagara, might probably be referred to the age of the limestone of Galt, Canada, since its fossils and other characters were similar; and perhaps a portion of the rocks of the north shore of Lake Michigan, hitherto supposed to be of the Niagara age, might be referred to the same age as the Galt limestone.

On the Plan of Development in the Geological History of North America. By JAMES D. DANA.—This paper was an application to the geological development of North America of views previously published by the author. Adopting the idea, that the shrinking of the earth's crust has been the direct agent in all the great geological changes of the surface, he regards the subsidence of the ocean basins as the immediate instrument in uplifting and corrugating the adjacent continents. He maintains that the typical form of a continent is a trough or basin, whose sides, raised into mountains, are so turned as to face the widest range of ocean, and that the height of those mountains, and the extent of igneous action along them, is directly proportioned to the size of the oceans.

Referring to the development of North America, we see the small Atlantic on one side, and the great Pacific on the other, making the relative amounts of force from the two directions, the south-east and south-west, during the progressive ages of the history, the former gently folding up the Appalachians, and the latter, with far mightier energy, raising the rocks and mountains, and opening the volcanoes of Oregon. Remarking that the area of Azoic rocks has something of a V shape, and opening towards the north, with Hudson Bay between its arms, Professor Dana considers this area as a stand-point against which the uplifting agency operated from the Atlantic and Pacific sides, the evolution of the continent taking place through the consequent vibrations of the crust, and the additions to this area, along its south-east and south-west sides. These two systems of forces—the south-east and south-west—continued to act until the close of the Tertiary period, when, having brought the continent nearly to its present form, they died out, or gave place to a northern force, which made itself felt in long and slow oscillations of the arctic regions during the Post-Tertiary period.

Notice of a remarkable instance of Inclined Stratification in Warren County, New York. By J. D. WHITNEY.—In the locality referred to, near Lake George, a fine white sand, containing small quartz pebbles, has been deposited over a considerable extent, and with a thickness of 25 feet vertical, having a dip of thirty degrees. The fact, thus established, that strata may be deposited at a high angle, led to the development of a theory of the formation and dip of the sandstones of the Connecticut Valley, and other similar deposits on the Atlantic slope of the Appalachian chain. The main point of the theory was this: that these beds of sandstone were originally deposited in an inclined position in a basin of subsidence, by currents of water carrying detritus, which currents were produced by the subsidence itself. If a fault originated in a valley, at one side or the other, and there should be a subsidence on that side, a current of water would be produced, of greater or less violence, which current would set across the valley, and carry with it the material abraded from the adjacent region, which would be deposited in strata dipping at a considerable angle, at right angles to the line of direction of the fault, as in the Connecticut Valley. According as the subsidence was to the east or the west, the dip of the strata would be in the opposite direction. Thus, the origin of limited basins of sandstone, having a dip transverse to the direction of the basin, would be fully explained by a cause lying within the basin itself—a phenomenon which had not as yet been satisfactorily explained by geologists.

On the Geology of the Broadtop Coal Region in Central Pennsylvania. By J. P. LESLEY.—The author stated, that he had made a nearly complete survey of the seventy or eighty square miles which it covers. The levels of more than nine thousand points upon the mountain had been obtained, and the structure made out with a fair approximation to accuracy. In another season the economical operations upon the mountain will be so multiplied that the minutest features of structure will become known, and a complete discussion of the fossils be possible. The present paper was intended to present only the fact and method of his survey, with its principal results. It has determined that the succession of the measure was not different from the system made out in Western Pennsylvania and Eastern Ohio.

On the Deposits of the Fossil Fishes and Reptiles of Linton, Ohio. By J. S Newberry.—Professor Newberry exhibited to the Section a series of fossil fishes of great beauty, and well preserved, derived from the Carboniferous strata of Ohio, from a locality which he had discovered nearly two years ago, and which rivalled, in the variety and beauty of its fossils, the famous fish-beds of Solenhofen or Monte Bolca. These fishes were, however, truly carboniferous (occurring near the centre of the Ohio portion of the Alleghany coal-field), both geographically and stratigraphically. The deposit was therefore to be compared with that of the fossil fishes at Burdiehouse in Scotland, so fully illustrated by Dr Hibbert. In the Ohio deposit was represented every genus found in the limestones of Burdiehouse, with a single exception; while in addition there were several genera not yet found in Scotland. The number of species was greater in the American than the Scotch deposits, and all were different. Nearly all the species had, however, a character common to those of Burdiehouse, in the elaborate ornamentation of their scales and plates, in which they differed from most of the fossil fishes of the coal series. He said the similarity of all, and the identity of many, of the fossil plants from the coal strata of Europe and America had been noticed, and now the general similarity of the fossil fishes still further indicated the synchronism of the Coal period on the two continents. These fish remains were found in a thin stratum of cannel coal lying at the base of a thick bed of bituminous coal. There was every reason to conclude that these fishes had inhabited a lagoon or space of open water in the coal-producing marsh, as within a mile or two in any direction the cannel coal and the fish remains ceased to be found; that in this lagoon the smaller fishes lived in great numbers, and, as their teeth proved, lived on vegetables. On these fishes, which were of the genera *Palæoniscus, Amblypterus, Mekolepis*, &c., the *Cœlacanths*, which were carnivorous, subsisted; while these, in turn, became the prey of the great sauroid *Megalichthys*, and of the sharks. These facts he inferred from the coprolites of the larger fishes being composed almost entirely of the scales and bones of the smaller species which had served them for food. Probably this lagoon communicated with the open ocean, where the sharks and rays, &c., lived. It had been evidently a favourite feeding ground with them, but by some means the entrance had been stopped, the lagoon dried up, partially at least, and the fish dying in great numbers about the same time, furnished us with so many beautiful, unmutilated specimens of old and young. Subsequently the surface was occupied by a growth of marsh vegetation, and the bituminous coal was formed without a trace of fishes.

In connection with this paper, Professor Newberry made some remarks on the mode of formation of cannel coals. He stated that an examination of the coal beds of Ohio, their changes from one outcrop to another, both in physical and chemical characters, had convinced him that the distinctive peculiarities of seams of this kind of coal are due to their deposition in water, and to the commingling of a considerable portion of animal matter with the macerated and dissolved vegetable tissue of which they are chiefly made up. That a resinous vegetation could have given its inflammable character to cannel, he thought improbable. He had found unchanged resin in bituminous coal, but never in cannel. The greater relative proportion of earthy matter in cannels would be an almost necessary result of covering the vegetable matter with a fluid heavier than air, and having greater power of transporting sediment. The appearance of the fossils previously noticed also seems to prove the aqueous nature of the origin of cannel. Pieces of cannel from England correspond with those in which these fossils are found. Shells, too, are not unfrequently found in the middle of a stratum of cannel. Among the vegetable remains found in this coal by Mr Newberry are *Stigmariæ* roots and rootlets of trees which grow in coal-producing marshes,—roots characteristic of the under class of the coal-seams, and others. Strata of ordinary bituminous coal usually consist of layers of greater or less thickness of brilliant bitumen, having a conchoidal fracture, alternating with thin layers of what is generally cannel, sometimes containing so much earthy matter as to become bituminous shale; at times these layers of cannel are of considerable thickness, and form an important part of the stratum. This arrangement is attributed to the variable quantity of water covering the coal-marshes—the cannel-like layers being deposited during the prevalence of higher water, when the fishy remains could naturally have become a portion of the stratum.

On the Organization of Acanthocephala. By Dr WEINLAND.—The anatomy of a worm would seem a matter of not very great importance. But those who have followed the development of science have seen that many little facts in the animal kingdom, and particularly observations made on the so-called lower animals, are just those upon which rests a great part of all physiology, including that of man. In those lower animals, in a worm, for instance, we have all the so-called physiological systems, the reproductory as well as the digestive and respiratory organs, in the most simple form. There we must study first all those processes which go on in what we call a living being. Two years since a very strange discovery was made in an intestinal worm in relation to its reproduction: and now this strange fact has become a law throughout the animal kingdom, including mankind. This, I think, is the true view of these so-called lower animals. I intend to speak to-day on the digestive apparatus of the acanthocephala, a sub-order of the helmintha, which apparatus I discovered last winter. There have, in zoology, remained still a large number of animals, which are said to have no distinct digestive apparatus. And this is certainly true of the rhizopodes, a family of infusoria—the lowest animals which we know. Let us look at such a rhizopod, of perhaps 1·400th of a line indiameter—a mucous matter, which may now have the shape of a round ball, now that of a star, without any skin around it, but with some globules in its body, which are swallowed as food balls. We remark near its margin a reddish dot;—this reddish dot is a heart, for it contracts once every minute. Now, how does this animal feed? There is no mouth, no intestinal canal. A friend of mine, Mr Capaside, has seen it eating. When another infusorium (for these are the food of the rhizopodes) comes into its neighbourhood, we see the rhizopod at once throwing all its body over it. and in the next second we see the prey in the centre of the rhizopod. A motion begins in the body, and a minute after, the eaten infusorium is a shapeless food ball. I have seen this myself once—a rare chance, for it eats only once in about ten hours. But there are said to be many other animals which rank much higher than the infusoria, who feed without mouth and digestive apparatus, by a mere imibition through the skin. Among others, till lately, all the sub-order of the acanthocephalous worms have been considered as having no mouth, no intestine. But last winter I found a mouth and two intestinal ears, starting from it and hanging down into the body, in four different species of this sub-order; and we can state, from analogy, that all this sub-order has a digestive apparatus like that other sub-order, trematoda. Its generally being found empty may account for its being overlooked for so long a time by naturalists.

On some Euphotides, and other felspathic rocks. By T. Sterry Hunt.—The name of *Euphotide* was applied to certain rock masses of the Alps and of Corsica, which were composed of an aggregate of a felspathic mineral, more or less compact, to which the name of *Saussurite* was given, and some variety of augite or hornblende, whose different nature has caused the rock to be designated as *hypersthenite*, *gabbro*, *granitone*, and *euphotide*, by different authors. The results of the author's studies of the so-called Labradorite rocks of the Laurentian system, show that these altered sedimentary deposits consist essentially of lime-felspars of the triclinic system, holding small and variable amounts of hypersthene or of pyroxene. The felspars vary in composition, yielding sometimes the formula of andesine, at others that of Labradorite or anorthite. Sometimes they are coarsely crystalline: in other cases fine-grained and almost impalpable, resembling Saussurite, and constituting, with their intermingled pyroxene, veritable euphotides, which pass by insensible degrees into the coarse-grained Labradorite rocks, with which they are chemically and mineralogically identical. In support of these conclusions, the author presented a series of specimens and a great number of analyses.

The altered lower Silurian strata of the Green Mountains present, in close association with serpentines, a series of fine-grained felspathic rocks, sometimes crystalline, and at others almost impalpable, which are found, on careful examination, to consist essentially of a triclinic felspar, having, in the case of the specimens exhibited, the composition of albite associated with an anhydrous silicate of lime, magnesia, and oxide of iron, having all the characters of hornblende. These rocks have a density of above 2·75, and form large interstratified masses in the vicinity of the serpentines. They are, according to the author, veritable euphotides.

Other felspathic rocks in the same series have the characters of petrosilex, and appear to be referable to the eurite of D'Halloy. The specimens exhibited were of a tough, dusty, sub-translucent greenish-white rock, having a density of about 2·64. The result of its analysis showed that it is to be regarded as probably an intimate mixture of quartz with felspar, having the formula of albite. The sedimentary origin of these deposits is undoubted, and the consideration of their metamorphosis presents many points of great interest.

On the Serpentines of the Green Mountains and some of their associates. By T. Sterry Hunt.—In this paper was considered the nature of the serpentines of the Green Mountains in Canada. The researches of Sir William Logan have fully established the stratigraphical position of the serpentine as belonging to that portion of the Hudson River group which contain the sparry limestones of Eaton. The serpentines are sometimes homogeneous, and are hydrated silicates of magnesia and protoxide of iron, without any admixture of carbonates, but frequently they assume the form of conglomerates, in which rounded or angular masses of serpentine are imbedded in a paste, which is a carbonate of lime, magnesia, and iron, constituting a ferruginous dolomite, at other times a nearly pure carbonate of lime. Diallage is often intermingled with the serpentine, or constitutes a rock by itself. The same series of rocks presents great beds of siliceous dolomite containing much carbonate of iron, at other times the lime is wanting; and we have magnesite rock, which is sometimes mingled with a large amount of nearly pure siliceous matter to which the carbonate series is a cement. At other times the siliceous mixture is a mixture of talc with a silicate resembling a felspar in composition. Small portions of oxide of chrome and of nickel are always found in the magnesites, and these two metals are also frequently found associated with the serpentines not only of Canada but of other regions. Associated with the serpentines, and sometimes intermingled, is a white massive rock, having a density of about 3·50, and being a silicate of alumina and lime, having the composition of a lime garnet; other specimens, having a density of 3·30 to 3·40, appear to be ultimate mixtures of garnet with a white pyroxene. The aluminous silicate in some of these rocks may possibly be related to idocrase or epidote. This remarkable variety of rock is evidently derived from the alteration of an argillaceous limestone, which has lost its carbonic acid, by a process precisely similar to that by which serpentines, talcs, and chlorites may be formed from siliceous and argillaceous magnesites, while the similar dolomites give rise to diallages, and asbestus, and hornblende rocks. As a general fact, it may be said that the original sediments contain all the ingredients necessary to yield the different species which are brought out by subsequent metamorphism—a proposition of the highest importance for the correct understanding of the theory of the metamorphic rocks.

Exhibition of Fossil Fish Remains from the Carboniferous Limestones and Coal-measures of Illinois. By A. H. Worthen.—The occurrence of these remains has up to the present time been considered extremely rare in the Mountain Limestones of the Western States; and except in the thin bands of limestone about to be described, they are among the rarest of the several beds that compose the sub-carboniferous series of the region under consideration. Several years since, while engaged in collecting the fossils of this formation near Warsaw, Ill., Mr W. observed a thin band of gray crinoidal limestone, which contained the palate bones of fish in considerable numbers; and subsequent research has revealed two more of these "platforms of death" lower down in the series, densely filled with these remains. The upper fish-bed is situated in the upper part of what Mr Worthen calls, for the want of a better name, the *Lower Archimedes Limestone*, since it is the lowest bed at present known to contain fossil corals of the genus Archimedipora. The remains from this bed, with one or two exceptions, consist entirely of palate-teeth, associated with cyathophylla-formed corals, *Spirifer oralis* and *Spirifer cuspidatus*. The middle fish-bed is situated at the base of this Archimedes Limestone and near its junction with the Cherty beds below. This bed has proved by far the most prolific in these remains, and from it Mr Worthen obtained more than five hundred well-preserved teeth at a single locality, and on a surface not exceeding ten feet square. The fossils from this bed are mostly jaw-teeth, with comparatively few palate-teeth and spines. The matrix in which they are embedded is a coarsely granular crinoidal limestone, not above four inches thick, and sometimes so friable as to be easily crumbled between the fingers. This character of the matrix enables the collector to obtain these delicate and beautiful fossils in a rare state of preservation. Beside the cyathophylla-formed corals in the upper bed, we have an interesting coralline form occurring in equal abundance, and belonging to a genus which he did not know. He also obtained the head of one species of Actinocrinus from this stratum. This bed is separated from the one above by the limestones and marlites of the Keokuk quarries, from 25 to 30 feet in thickness. The lower fish-bed is situated near the top of the Burlington crinoidal limestone, and the stratum in which the fish-remains occur does not differ materially either in its lithological or palæontological character, from the associated strata. This crinoidal limestone forms the base of the mountain limestone series in this region, and rests directly upon rocks equivalent to the Portage and Chemung groups of New York. This lower bed has yielded a great number of teeth, though they are usually of smaller size than in the upper beds. This stratum was first observed at Quincy, Illinois, and has since been recognised in Henderson County, in the same state, and at Augusta, in Iowa, points nearly one hundred miles distant from the one first named, showing that these fish-beds are not local. This bed has also afforded one well-marked bone nearly four inches long. From these specimens it seems that the fishes of the sub-carboniferous era increased in size from the beginning to the end of that period, and that by far the greater portion of them were cartilaginous, only two well-marked bones having been obtained from at least one thousand well-preserved teeth. The *Pentremitæ* and *Archimedes* limestones of southern Illinois have afforded several very fine specimens of fish-remains, but a very careful examination has not yet revealed any strata in which they occur in such profusion as in the lower beds. Going south through Tennessee and Northern Alabama, though this formation attains a thickness of more than one thousand feet in the valley of the Tennessee River, these remains are exceedingly rare, and a careful research of several days yielded only three or four specimens of this class of fossils. An interesting inquiry arises as to the causes which destroyed such great numbers of the vertebrated inhabitants of the ocean during the deposit of the thin bands of limestone in which their remains are entombed in such numbers. Unlike the *Ichthyolites* of the Old Red Sandstone below, and the Lias and Chalk above, those of the mountain limestone, now before us, only occur in the fragmentary condition of isolated teeth and spines, affording in themselves no clue to the causes which may have operated in their destruction, and leaving us to conjecture whether they fell victims to disease, or to an injection of heated water or noxious gases into the ocean in which they lived. From the want of authorities and foreign specimens, Mr Worthen has not attempted to identify these fossils with similar ones in Europe. Still we may reasonably expect that, when all these collections have been fully collated, many new species will be added to those already known to occur in the upper Palæozoic. The fossils presented were only a small part of those which had been collected in that region.

Professor Agassiz alluded to the fact that two varieties of fish-remains are found belonging to the same geological period. The differences found in these proved to him the fact that they must have lived in waters of a different nature—in other words, that one variety belonged to fresh or brackish water and the other to salt. These specimens brought by Mr Worthen are precisely like those of Ireland; those brought by Mr Newberry are like those found near Glasgow in Scotland. Mr Worthen's he holds to be truly marine; it is now to be found alive only as a marine fish, and in certain parts of the Pacific. These fishes have no skeleton, and of course, after death, unless preserved by some extraordinary conjuncture of circumstances, will entirely decay, excepting the teeth, and possibly a bone or two, and the two hard spines of the dorsal fin. Of these spines he found two specimens among these remains. Though he had studied the best collection of fossil fishes in Europe, yet this one affords the means of beginning the study anew, and gaining new information upon the subject. These fragments will enable the Naturalist to go further in reconstructing the animal than all the others. In one of these specimens he finds two teeth, connected in such a manner as to show him that marks which he has formerly published as proving the existence of two species, are in fact those of a single one. He thought this collection so fine and valuable as to be worth having every specimen carefully depicted. The *Lepidosteus* of this collection is now found alive only in the rivers of Senegal; and as it there never descends into the salt water, he infers that these must also have been fresh-water fish.

On the Relation of the Post-Permian Fishes of Connecticut and other Atlantic States to the Triassic and Jurassic periods. By J. H. Redfield and W. C. Redfield.—This paper refers in some detail to the previous publications of Mr J. H. Redfield and Mr W. C. Redfield, on the fossil fishes of the sandstone belt of some of the Atlantic States. The nearly homocercal character of some of these fishes was, in 1837, remarked upon by the former as "implying for the formation even a higher place in the series than that assigned it by geologists," (New Red). And in a report to the American Association in 1845, which has remained unpublished, he infers, from like evidence, that the including rock cannot be older than the triassic, while it must be placed at least as low in the series as the lias or oolite.

Mr W. C. Redfield, on the ground of the homology of caudal structure, reclaims the *Dictyopyge* of Egerton, founded on his *Catopterus macrurus* as still belonging to the genus Catopterus. In a postscript, he adds, that he finds the remains of Catopterus brought from the North Carolina belt by Professor Emmons to be scarcely distinguishable from most of those of the Connecticut and New Jersey rocks.*

Permian and Triassic Systems of North Carolina. By Prof. EBENEZER EMMONS.—After describing the chief lithological features of the rocks composing the two sedimentary belts here referred to, the author stated his reasons for regarding them as made up of portions belonging respectively to the Permian and the Triassic systems. In what he described as the lowest of these groups, he had found remains of Thecodont Saurians. The teeth of the Saurians are in sockets, the vertebræ are concave at both ends, and constricted at the sides, the ribs are double-headed. Several of the teeth agree with those of *Clepsysaurus pennsylvanicus*. One tooth he regarded as belonging to Palæosaurus. Another specimen presented what he thought to be the plates of the head of Archagosaurus. These specimens are found, some embedded in coal and some in hard rock. Along with them is a minute Cypris, and among the coal-measures a variety of plants. This division Professor Emmons regards as *Permian*. The group of rocks above this containing Cycadeæ, Voltzia, and Walchia, he refers to the *Keuper*.

MR WM P. BLAKE *read a paper on the Orography of the Western portion of the United States, illustrating it with a map.*—It was but a few years, he said, since the vast territory lying between the Mississippi and the Pacific was an almost unknown region. The recently completed surveys made to determine the most practicable railroad route to the Pacific have added largely to our previous knowledge. Eight expeditions have been sent out, each with an independent outfit, instructions, and line to survey. They crossed the country at different parallels of latitude, and their routes were selected with reference to the unexplored spaces. The result of these surveys filled up nearly all the previously blank spaces on the map of the territories. The position, direction, and altitude of ranges of mountains not before described had been made known. The direction and position of a part of the Great Colorado and other rivers have been changed, and the boundaries of the Great Basin restored to the limits originally assigned by Fremont. As the attention of the surveys had been specially directed to the determination of altitudes and grades, and a large number of accurate instruments had been provided for this purpose, the results were unusually interesting in an orographic point of view. The materials which had been collected at the date of publication of the preliminary report were sufficient to admit of the construction of five profiles of the country from the Mississippi to the Pacific. These were reduced to one scale, and published on one sheet, under the direction of the Secretary of

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* It will be seen that these inferences harmonize with the conclusions drawn by Professor W. B. Rogers, from an examination of the vegetable remains of the eastern belt in Virginia, and from his subsequent discovery in this and the other belts of certain common fossils, especially Cypridæ and Posidonomyæ. The former inquiry led him, in 1842, to assign to the eastern belt of Virginia a position low in the Jurassic series, and the latter has more recently led him to place the western or great prolonged belt, on a horizon but little lower than the former, near, but still above, the upper limit of the Trias. The discovery, lately, by Mr E. Hitchcock, of a Clathropteris in the Connecticut sandstone, lends further support to this view.

War. It is from these new materials, combined with the results of previous explorations, that Mr Blake had prepared the map which was before the Association. The great number and wide distribution of the mountains, and the variety of names under which the same chain is known at different places, make it necessary to consider them in groups, in order to facilitate descriptions and comparisons. They are separated by nature into three great divisions, which may be described as follows:—The first group consists of the great line of water-shed between the Pacific and the Atlantic Oceans, commonly known in part as the Rocky Mountains, extending from the table-land of Mexico to and beyond our northern boundary. The second may include the Sierra Nevada of California, and its prolongations, south into Lower California, and north into Oregon and Washington territories; also all the ranges between this chain and the coast—the coast-mountains of California. The third is composed of the numerous and broken ranges lying between the first and second groups. The first group is sufficiently characterized by being the dividing ridge or crest of the continent, from which the waters flow each way into the Pacific and Atlantic. The second is characterized by its lofty and unbroken line of snowy peaks, forming a great wall along the Pacific; and the third is well separated from the first by the valleys of the Colorado and Green River in the south, and Snake River in the north, while on the west it is separated from the second group by the well-defined line of snowy heights of the Sierra Nevada, and further south by the low valley of the Colorado Desert and the Gulf of California. Two other groups may be formed, of the long line of azoic rocks extending northwest from the Great Lakes, and of the Appalachian chain, and its extensions through New England and Canada, and thus the principal chains of the Continent will be included in five groups. We find the northern portion of the first group to be composed of three principal and nearly parallel ranges:—the Rocky Mountains proper, the Bitter Root Mountains, and the Cœur d'Alene Mountains. The last two ranges are intersected by the head waters of the Columbia River, but they are very properly referred to this group. The Bitter Root range extends from about lat. 46 deg. to Clark's fork of the Columbia, and is prolonged beyond it to the eastern side of Flatbow Lake, where it is known by another name. A parallel chain, or possibly a portion of the same, is called the Kootanie Mountains. The Bitter Root range is considered more lofty and rugged than the Rocky Mountains, with which it is joined by the dividing ridges between the Bitter Root River and the Jefferson fork of the Missouri. The Salmon River Mountains, further south, may be regarded as connected with these ranges. The Rocky Mountains proper extend in our territories from the boundary in a direction S. 20 deg. E., 260 miles to lat. 46 deg., where they curve to the south-west and unite with the Bitter Root range. From this point south there is but one range, of which, however, very little is known, until it unites with the Wind River Mountains, which extend S. 40 deg. E. for about 170 miles to the depression known as the South Pass. In this range we have the highest point in the group (Fremont's Peak) 13,570 feet in altitude. From the end of this range to the next there is a wide interval without any mountains. The country is a table-land or gently rolling prairie, 7500 feet above the ocean. About 140 miles S.E. we find the ranges again in parallel ridges, trending southerly, and inclosing wide rectangular valleys known as the Parks. The first. Medicine Bow range, is nearly coincident in direction with the Wind River Mountains, and is separated from a parallel range by the head waters of the Platte. These mountains, south of the Medicine Bow range, display on the maps a singular rectangular intersection of the ridges, arising partly from errors of drawing. These mountains are known as the Park Mountains, and extend south to the sources of the Arkansas River. Some of the highest points of the group are here, such as Pike's and Long's Peaks. The long ridge usually represented between Fort Laramie and Fort Union, called Black Hills, does not exist, as recently determined by Lieutenant G. K. Warren. The great central chain in the territory of the United States is about 1400 miles in length, consisting principally of ranges running about N.N.W. and S.S.E.

Mr Blake remarked that the great range of the Sierra Nevada was not one continuous ridge or snowy crest, as is generally supposed. It is formed of many nearly parallel ranges, which inclose elevated valleys, precisely as in the Great Basin. The northern part of the Sierra is flattened down into a broad table-land. This plateau, in the vicinity of the Madelin Pass, has an elevation of about 5000 feet, and a width of some twenty miles; it is walled in by ridges on each side, rising from 500 to 3000 feet higher. This plateau is broken by short ranges; but it extends northward into Oregon, to the numerous small lakes about Lake Albert. A chain of lakes, in fact, occupies the lower portions of the plateaux for the whole length of the chain, and shows the great amount of precipitation on the summits. The passes through these mountains generally turn the points of the isolated ridges, or cross them at their lowest point. In passing southward along the crest, the elevation of these mountains increases, as shown by the observations of those who have searched for a location for a waggon-road. Thus Fremont's or Carson's Pass, traversed by Fremont in 1844, is nearly 8000 feet high, and one from Sonora, across to the basin, is 10,033 feet in height. Further south the chain trends to the west, and its altitude decreases, preserving, however, its broken character. Here were high valleys wooded with oaks and covered with grass. This plateau is about 3500 feet high, and the passes from 4000 to 5300.

In the Great Basin mountains, the principal range is known as the Wahsatch Mountains, which form the eastern rim. Between this and the Sierra Nevada there is a constant succession of ridges, which are short and much broken, arranged in parallel lines, and generally trending north and south. The general surface of the Basin has an average elevation of 4500 feet, and these ranges rise from 1500 to 3000 feet higher. Midway between the Lake and the Sierra, swells up the Humboldt Mountains, reaching an altitude of 9000 or 10,000 feet, the summit of the principal pass being 6579 feet high. He proposed to call the grand central chain, extending from the Andes to the Arctic Ocean, the Anahuacian chain, since it might be said to commence in the south, where it formed nearly the whole of the table-land of Mexico, or Anahuac. The second chain, traversing the two Californias, and including its northern prolongations, the Cascade ranges, he thought a more appropriate name could not be found for than the Californian chain. For the third group he suggested the general appellation of the

Aztecian chains, or Great Basin chains. These names harmonized with the elegant general title of Appalachian, proposed for the Alleghanies and their extensions by the Messrs Rogers, a name which had now passed into general use. The two great chains were each about 1500 miles long in the United States territory. The Californian chain extended along the peninsula 800 miles further south, and the Anahuacian became the table-land of Mexico. The greatest breadth of surface covered by these chains was along the parallel of 40 deg. from the meridian of 105 deg. 30 min. to 124 deg., or about 1200 miles. This, however, includes the elevated table-land at the sources of the Colorado. The breadth diminished both toward the north and the south. Comparing these two chains, we were struck by their general and close parallelism throughout, even the irregularities of one chain finding their counterparts in the other. The parallelism of the coast-line with the mountains was also interesting, the coast-line being formed principally by erosion, and not, as our Atlantic sea-board is, by deposition. One of the most important characteristics of these chains was the great number of ridges of which they consisted. These ridges were not ranged exactly side by side; they generally overlapped each other. This distribution *en échélon* was not a new feature; it was found in the Appalachians, and was one of the results of the earth's contraction, which, according to the theory so ably sustained in this country by Professor Dana, was the cause of the great plications of the crust. This overlapping was very well shown in the Coast Mountains of California, where the ranges reached the coast successively from the south northward. The Bay of Monterey is included between the end of the projection of one ridge into the ocean at Point Pinos, and the side of another which ends much further north. This parallelism and overlapping of the ridges, as in the Appalachians, show that forces similar to those which formed the Appalachian chain have been here exerted on a much grander scale. Instead of one chain we have several, each rivalling the Alleghanies in extent and altitude. The folding of the rocks is not only inferred from the topography of the ranges, it has been found in the Sierra Nevada and Coast Mountains of the Californian chain, as well as in the chains of the Great Basin. We cannot contemplate the peculiar relations of the principal chains, as exhibited in the map, without recognising the result of the action of two opposing forces. If we conceive the principal lines of flexure to be meridional, north and south, the folding may be referred to a force of contraction, acting in east and west lines, and this may be termed the equatorial contraction. The trends of the ranges show also the action of force in another direction, or from north to south; a polar contraction, to which the sudden bends in the long chains of mountain may be referred. These bends are found in the Sierra Nevada, east of the Bay of San Francisco, in its southern portion, where it curves gradually round to the south-west; and in the Bernardino Sierra trending at nearly right angles to the Sierra Nevada. Parallel deflections are found in the Anahuacian chain in the Wind River range, and again they are seen in the Wahsatch range of the Aztecian chains. Thus all the long chains are bent, as if by compression, upon the ends; and the action of a force exerted at right angles to the force which has produced the prevailing meridional folding is clearly shown. It is most probable that this force has acted in north and south lines, and we may term it the *polar force* or contraction. The overlapping of the ridges and ranges is another evidence of this polar contraction; for we see that it is nothing more, to speak in general terms, than the sliding of portions of the range upon themselves—at least the appearance presented is the same, although there is perhaps no actual break. We may also refer the great north-west and north-east trends to the interference of this polar force or resistance,—either producing the same result with the equatorial contraction,—the diagonal trends being the resultants of the two forces.

The Proceedings of the Royal, Royal Physical, and Botanical Societies are unavoidably postponed for want of space.

SCIENTIFIC INTELLIGENCE.

ZOOLOGY.

Die Schmetterlinge des Südwestlichen Deutschlands. Von G. Koch. 8vo. Cassel. 1856.—One volume, written entirely in German, and apparently a useful work for the local entomologist.

Die Mikroskopische Zouna des Septarienthones. Von Hermsdorf bei Berlin. Von Dr J. G. Bornemann. 8vo. Berlin. 1856.—The text entirely in German, illustrated by ten beautifully-executed plates.

Mr Yarrell's Collections.—Mr Yarrell's ichthyological collections have been purchased in one lot, by Dr Gray, for the British Museum, for L.126, the New Museum at Oxford being the other bidder for it. This collection contains the type species of the History of British Fishes and those described in Mr Yarrell's papers; and it is of importance that they have been placed in the national collection, and will thus become accessible to those who may wish to compare and consult them.

American Oology.—"We have in the press the first part of Dr Brewer's great work on *American Oology*. It will include the rapacious birds, and perhaps the swallows. There will be five quarto plates to this part; all the figures taken in photograph, from the original eggs, and printed in colours. The result is extremely beautiful and accurate."—(*Letter from Dr Baird, Smithsonian Institute, Washington.*)

Viviparity and Oviparity.—At the American Association (Albany) meeting, Professor Agassiz made a communication on viviparity and oviparity, "on which his researches in embryology have thrown great light. At one time it was believed that those animals which brought forth their young alive had peculiarities which indicated exclusive relationship. The progress of embryology had proved that there was no such relationship, and no radical difference between viviparous and oviparous animals. In the family of snakes there were viviparous and oviparous genera. The vipers brought forth their young alive, but they were not on that account like quadrupeds. Among quadrupeds, too, the marsupials, when first born, were carried about by the mother, attached to the nipple, until they were capable of being again born, and, as it were, standing on their own legs. Placental connection between mother and young was of not much consequence. Sharks showed that; some being oviparous, others viviparous, with or without placental connection. Yet the mode of development in all was precisely the same, and was a shark development. There was a nothing in it which was allied to that of birds. This had a decided influence on classification. There was no reason for separating the marsupials from other mammals. In each group and different class the relation between the modes of development indicated the real relations of the animals. Animals which were developed in the same manner were sure to be found in the end to belong to the same general division. He maintained that the distinctions founded on complications of structure must be given up for general classification, and confined to the minor distinctions.

BOTANY.

On the Law of Phyllotaxis.—The following is an abstract of a paper on the above subject, read at the last meeting of the American Association, by Dr T. C. Hilgard :—The author endeavours to construct a theory of the cause of Phyllotaxis or arrangement of leaves. Hitherto, Phyllotaxis has only been studied in its mathematical relations, and in its analogy to cosmical or to zoological order. It had been shown that leaves not opposite are arranged about a stem always in either two, three, five, eight, or thirteen rows, and that if the bases of the leaves taken in their order of height on the stem be connected by a thread winding round the stem, then between any two successive leaves in a row, the thread winds round the stem once if the leaves are in two or three rows ; twice, if in five rows ; three times, if in eight ; five, if in thirteen, &c. In other words, two successive leaves on the thread will be at such a distance, that if there are two rows, the second leaf will be half way round the stem ; if three rows, the second leaf will be one-third of the way round ; if five, the second will be two-fifths of the way round ; if eight, three-eighths ; if thirteen, five-thirteenths, &c. But the question of Dr Hilgard is, why is this so ? What is the organic law of development that produces this result? If we cannot anwer this question, can we not, at all events, throw some light upon it, or give some hint towards its solution ? If we take a flower-stalk of the common plantain (*Plantago major*) between the thumb and fingers, we can, by twisting the stalk in one direction or the other, arrange its buds in any number of rows that the law of Phllyotaxis permits, two, three, five, eight, &c. As we can thus pass from a higher to a lower number, or from a lower to a higher, at pleasure, by simply twisting the stalk, that is, by introducing a constant disturbance at every point of the stalk, it is plain that the mathematicians will allow the organic law to be founded either upon a very high number of rows, which, by a constant interference, is reduced to smaller numbers, or upon a low number, which is modified into higher ones. The former had been the view of Professor Pierce, in his paper presented to the Cambridge meeting in the United States, viz., that the organic law of vegetable growth contained, as a fundamental constant, the surd towards which the series ½, ⅓, ⅖, ⅜, &c., approximates ; and that interferences with it, constant, or nearly so, in each botanical species, produced the approximations. Dr Hilgard, on the contrary, seeks for the germ of the law of Phyllotaxis in the numerical genesis of cells. Starting with a primal cell generating a second, and assuming that the second requires a time to come to maturity, during which the primal cell recovers its powers and produces a third, we have a law which gives the Phyllotaxian numbers. *One* cell generates a *second*, and then a *third*. The first and second then simultaneously generate each one, which makes the whole number *five*. The first, second, and third are then mature enough to generate each one, which make the whole number *eight*. Five are then sufficiently mature to generate each one cell, which raises the whole number to *thirteen*. Here, then, is a simple mode of conceiving of the genesis of cells, which gives us at once the numbers that occur in Phyllotaxis, and no others. But, we need also the geometrical element, the position as well as the number of the leaves; and if we can obtain it from this same conception of numerical genesis it will be a strong confirmation of the theory, that this lies at the foundation of this organic law. Now, if we take a rosette of the houseleek, for example, and number the leaves of the whorl in Phyllotaxian order, we shall find the successive numbers actually placed in juxtaposition to those which in our law of cell genesis would be their parents; that is, 4 and 5 will be placed at the base of 1 and 2; 6, 7, and 8 at the base of 1, 2, and 3, &c. This conception of numerical genesis fulfils, therefore, the geometrical conditions required, and thus asserts its claim to a fundamental position in any theory of the organic law of vegetable growth.—(*Wells' Annual of Scientific Discovery.*)

Reproduction of Spheroplea Annuline.—Cohn says, that the grains of chlorophyll in this plant unite together and form groups nearly equidistant; around them a mass of endochrome collects, then the cell of the plant divides by partitions into distinct compartments, each containing one of these groups, which assumes a star-like appearance. The compartments then become filled with utricles of different sizes and forms, the chlorophyll disappearing more or less completely. Finally, openings take place in the membrane of the common cell containing the utricles. The utricles or cellules become filled with chlorophyll, but in their early state they have no proper membranous envelope. In this state they are primordial spores fit for fecundation. Spermatozoids enter by the openings in the mother cell, and move rapidly about. Fecundation is effected, and after this the spores become covered with a proper integument. The chlorophyll in the fecundated spores becomes first orange, and then red. The green filaments of the male cells assume a reddish tint, and this substance is resolved into spermatozoids. These are detached from the mucilage which envelopes them, and move rapidly round the large vacuoles in the mother cell. The spermatozoids finally issue by openings from the large mother cell.

On the Reproduction of Œdogonium.—Pringsheim has examined the reproductive process in two genera of minute algæ, Œdogonium and Bulbochæte. The greater part of the cells of Œdogonium contain each a zoospore, provided anteriorly with a complete crown of cilia. This body (the zoospore) is produced without sexual intercourse. It germinates, and gives rise to a new plant in the same way as the bud does. Between the common cells of the plant occur other utricles, usually more swollen, either isolated or in groups. In these are formed motionless spores, which are the female sexual organs. In the individuals which produce these female cells, as well as in others which have no such cells, there occur a third kind of cell, shorter than the common cell of the plant, and forming irregular groups. This third kind gives birth to spermatozoids, either at once or after the appearance of an intermediate production of a special nature, which becomes detached from the primordial filament, and contains the male sexual apparatus.

In *Œdogonium ciliatum*, a small species found attached to the leaves of aquatic mosses, the cells containing the male organs are found towards the anterior extremity of the filament, between the setiform terminal cells and the upper female organ. In each of these cellules there is formed at the expence of the contained plastic material a single small zoospore-like body called *microgonidium*. This, according to Pringsheim, is the antecedent or generator of the male organs, and he calls it an *androspore*. These androspores, furnished with a circle of cilia at their anterior and transparent parts after quitting their mother cells, move about at first, and then become fixed, in a determinate manner in each species, either to the female organ itself or in its neighbourhood. Pringsheim has seen in *Œdogonium ciliatum* several androspores fix themselves on the surface of the female organ. The female organ continues to be developed, while each androspore becomes a sort of compound cellular plant. In one part of it, the spermatozoids are formed; this part may be called the proper antheridium.

The fixed androspore acts like a mother cell. The antheridium, properly so called, represents the secondary utricle produced at the upper part of the androspore, and the stalk of the antheridium is formed by the secondary inferior utricle. The antheridium bears at its summit a small lid, formed from the upper part of the membrane of the androspore. The antheridium, at first unicellular divides into two cells, which become the mother-cells of the spermatozoids. The whole plastic contents of each mother-cell are employed in the formation of a single spermatozoid of considerable size. When the spermatozoids are mature, then the upper spermatozoid raises slightly the lid of the antheridium. In the meantime, the female organ is going through a process of development. When its contents are mature, the membrane of the female organ is ruptured all at once a little below its summit, the upper part (forming a sort of lid) and the filament which surmounts it, are turned to the side by the swelling of the plastic contents. There is thus a space in one side between the lid and the lower part of the female organ; then the mucous and colourless portion of the endochrome protrudes from the aperture, and its colourless cellular membrane presents a distinct lateral opening, turned towards the antheridium. When the female organ has undergone these and further changes in its contents, the lid of the antheridium is completely detached, and allows the upper cuneiform ciliated spermatozoon to escape. This spermatozoon, after moving around the female organ for some time, enters the opening, reaches the female globule which is to be fertilized, and seems to be absorbed in its substance; after this the female globular body becomes more and more definite, and finally becomes surrounded by a double membrane.

Biography.—Jules Thurmann was born at Neuf-Brisack (Haut-Rhin) on 5th November 1804. His father died 15 months after his birth, and his mother returned to her native city, Porrentrui, with her son, who passed his early period of study there. He afterwards went to Strasburg and remained there four years, prosecuting chiefly the study of mathematics and of law, and receiving the degree of Bachelor of Letters. He subsequently studied in the Ecole des Mines at Pau. He afterwards returned to Switzerland, and studied for 18 months at Constance. Here he devoted his leisure hours to botany and geology.

In 1830 he returned to Porrentrui, and continued to prosecute his geological researches. In 1831 he took an active part in the organization of the geological portion of the Museum at Strasburg, and in 1832 published in the Memoirs of the Nat. Hist. Soc. of that city, his first paper, *Sur les soulècement Jurassiques.* In 1832, he became a member of the administration of the College of Porrentrui. He made many improvements in the College, instituted a mineralogical collection, and became Professor of Mathematics and of Natural Science. He was one of the founders of the Statistical Society of the Jura district. He prosecuted his geological researches in the Jura Mountains, and brought his theory as to their elevation under the notice of the Scientific Association, which met at Stuttgart and Soleure in 1834 and 1836. He was now nominated director of the Normal School of Jura, was elected a member of the Geological Society of France, and presided at the meeting of that Society held at Porrentrui in 1838. In 1843 he resigned the direction of the Jura School and retired into private life, with the view of prosecuting his scientific researches.

He published several scientific papers in the Memoirs of Societies; such as an account of the Vascular Plants of Porrentrui,—Observations on periodical Phenomena in the Bernese Jura, &c. His great work, however, was his "Essai de Phytostatique Appliqué à la Chaine de Jura," or the Influence of the subjacent rocks on the dispersion of Vascular Plants. In 1853 he brought this subject under the notice of the Helvetic Society of Sciences which met at Porrentrui, under his presidency. He continued his geologico-botanical researches to the close of his life. He was preparing to take an active part in the meeting of the Helvetic Society at Chau-de-fonde, when he was attacked by cholera, which cut him off, 24th July 1855.*

Botanical News.—It is expected that the French government will purchase the Herbarium and M.SS. of Jussieu. The Herbarium is extensive and contains interesting notes by Jussieu, as well as by Lamarck, Poiret, and others. The M.SS. are valuable. They embrace among other things the journal of Gundelkheime, the companion of Tournefort; the MS. of Tournefort on the Flora of Paris, many papers by the elder Jussieu, and his correspondence with Linnæus, &c.

M. Alphonse de Candolle is now printing the Memoir of M. Meisner on the Thymelæaceæ for his Prodromus.

M. Cosson is continuing to publish his Flora of Algeria, and is about to take a fourth botanical trip into that country. He proposes to examine the numerous oases of the so-called Desert of Sahara. On the mountains of Atlas at each journey species have been discovered which were supposed to be peculiar to Egypt or Arabia.

The expedition of Mr Richard to Higher Egypt has not as yet afforded good results.

Preservation of Timber.—The Permanent Way Company, 26 Great George Street, Westminster, are employing with success Dr Boucherie's method of preserving timber. Solutions of preservative substances are introduced by the patent process into various kinds of timber, in such a way as to expel the fermentescible sap, and substitute matter less liable to undergo destructive changes. It has been found that sulphate of copper, dissolved in the proportion of at least 2¼ lbs. to 22 gallons of water, is the best preservative. It is said that white pine thus impregnated with sulphate of copper, placed in the ground as railway sleepers. or exposed to the action of the air, lasts longer than oak unprepared placed in the same situations. The Directors of the Chemin de Fer du Nord state, that Dr Boucherie's process has produced most satisfactory results as regards sleepers when completely prepared. Those in use since 1846 were as good in 1855 as when laid down. The sleepers are Beech, Hornbeam, Birch, and Pine. The posts for the telegraphic wires prepared by this process, have also shown great durability. The process thus appears to impart durability to woods which are cheap and abundant.—(*Reports on Boucherie's Patent; Permanent Way Company.*)

CHEMISTRY.

On the Composition of the Phosphate of Lime found in Waters naturally.—The following is a brief abstract of the results obtained by Dr A. A. Hayes in his experiments on the subject.

Where bones immersed in water, either pure or saline, are exposed to the temperature of 80° F., a fermentative decomposition of the tissues of the bones commences and continues for some time. The gases evolved are mixed with the acids and ethers usually produced in the decomposition of muscle, and the sulphur compounds are also present, air being freely admitted. The fat-cells of the tissues become broken, fats and oils are separated, while a superficial breaking-up of the structure of the bone occurs; translucent bones, like fish bones, become more opaque, and an evident chemical change of composition advances.

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* Actes de la Société Helvetique des Sciences Naturelles, 1855.

The water becomes grayish in colour from suspended matter, and contains the whole series of acids known to attend organic decomposition in presence of azotized compounds, but,most remarkably, it is *alkaline* in its action on test papers. At a certain stage of the action, *no ammonia is present as a base.* The fluid either frompure water, or saline, or sea-water, will bear heating to 200° F., and a coagulation of albuminous compounds ensues, *the fluid remaining alkaline.*

Tested for bone phosphate of lime, this salt is found to be present in the same proportion as we find dissolved from recent bone by warm water digestion, and without further examination the case might be passed as one of simple solution of bone phosphate in a gelatinous solvent.

If an excess of ammonia be used to separate the bone phosphate dissolved, and a moderate heat, or even boiling, be resorted to, the whole of the bone phosphate can be separated, leaving a clear fluid, which, thus deprived of most of its organic matter, readily passes the filter.

On adding to this filtered solution an ammoniacal solution of lime, an instant abundant precipitation of a hydrated salt takes place to such an extent that the whole fluid becomes a jelly in consistency. This salt is principally bone phosphate of lime, crenate of lime being present, besides other organic salts of lime.

The *phosphoric acid* thus separated from the bone in putrefaction, leaves the lime base in the presence of arsenic and other organic acids, for the carbonic acid to unite with and form carbonate of lime, at the same moment *phosphoric acid dissolves in the fluid without preventing an alkaline re-action.*

Recently prepared bone phosphate of lime can be decomposed by a current of carbonic acid in pure water; the bicarbonate of lime separates partly as carbonate and partly remains in solution. Ammonia causes bone phosphate to fall, but the filtrate contains much phosphoric acid, which is uncombined with an earthy base.

The fluid which dissolves phosphoric acid from the bone, also holds a small quantity of bicarbonate of lime in solution, but the alkaline action is not wholly due to the presence of this compound. It appears that a portion of protein or other animal organic base holds the phosphoric acid engaged at the moment of its separation.

In two cases of poisoning by phosphorus, which were chemically examined by Dr Hayes, the contents of the stomach. and even the parts of the tissues, altered by the phosphorus were strongly alkaline. Both cases afforded a compound in which the phosphorus as phosphoric acid was in union with organic matter.

This elimination of phosphoric acid in the progress of putrefactive fermentation, explains, as had been done, the formation of rock guano. It shows us how readily bones give to sea water and other waters their phosphoric acid. In connection with physiology, the experiments show that phosphoric acid may exist in the tissues, although the compound be alkaline or neutral, and that a phosphate may pass away or be so placed without the disturbance which might have been expected.

Wohler has more recently shown the solubility of bones in water, but it is possible the beautiful decomposition here described may have escaped his attention.—(*Wells' Annual of Scientific Discovery.*)

Tests of Strychnine and Brucine.—Extract Letter from Dr Traill to Professor Balfour.—Among your articles of intelligence you may add, as a sequel to my remarks on *strychnine*, what was unfortunately omitted in that communication, that *brucine*, the alkaloid most nearly allied to strychnine, is easily distinguished, by the test of chloride of gold added to the acetates of both. With that test strychnine gives a copious, rich, gamboge-yellow precipitate; but with brucine there is no precipitate whatever, and the mixture assumes a deep reddish-violet colour.

The most delicate test, however, of strychnine is Dr Marshall Hall's, the limbs of a frog, which are thrown into violent convulsions by the smallest atom of strychnine.

A New Gun Cotton.—A correspondent of the American Journal of Pharmacy (Mr Caldwell) describes a new kind of gun cotton, which is made as follows:—Newly prepared gun cotton is placed in a saturated solution of chlorate of potash, and allowed to remain for fifteen minutes. It is then gently pressed between folds of clean linen rag, and dried over a heat of 150 degrees. The cotton thus prepared explodes much quicker, and more like fulminating silver, than the ordinary gun cotton. From some experimental shots the result was as follows:—A pistol loaded with nine grains by weight, of the ordinary cotton, sent a ball about half through a yellow pine door one inch thick, at the distance of twenty feet. It was then fired with two grains of the cotton, treated with chlorate of potash, when the pistol was shattered to pieces. Another pistol was loaded with one grain of the cotton, when the ball passed entirely through the door, making a perfectly smooth perforation.

GEOLOGY.

Kidderminster Deposits.—We have received information from the President of the Malvern Natural History Field Club (Rev. W. S. Symonds), that the equivalents of the Caithness, Lesmahagow, Kington, and Ludlow tile stones, or transition beds between the Ludlow and Old Red Sandstone deposits, have been lately discovered by Mr G. E. Roberts, of Kidderminster, three miles north of that town. The organic remains are most abundant. The Pterygotus and Eurypterus are found in the same bed with *Cephalaspis Lyellii*, and are associated with beautiful specimens of molluscan or crustacean spawn, probably the latter. Terrestrial plants, apparently allied to Equisetum, are imbedded with the fossil seed-vessels of Lycopodiaceæ, determined by Dr Hooker from the bone bed of Ludlow, with many other fossils yet to be described. The persistence of this bed throughout so large an area is very extraordinary.

Generalities of the Geology of Northern California and Oregon.—At the Albany meeting of the American Association, Dr Newberry gave a general view of the geology of Oregon and that part of California lying north of San Francisco, and of the age and structure of the three ranges of mountains which, he said, gave character to the topography of the Far West, and of the valleys which lie between them. These "valleys," he said, were rather plains or plateaux than valleys. The Sacramento Valley was a plain lying between the Coast Range and Sierra Nevada—for the most part destitute of trees—through which the river ran with tortuous course, like a brook in a meadow. In the lower part of the Sacramento Valley there were no rocks older than tertiary; but at the head of the valley he had found the carboniferous limestone, clearly marked by its characteristic basalts, on which were lying the cretaceous and tertiary strata, precisely as on the Upper Missouri.

Crossing the volcanic spur of the Sierra Nevada connecting Mount Shasta with that great chain of mountains, he had descended into the Klamath Basin, which he said formed an appendage to the great basin of the Salt Lake, and was a plain somewhat cut by subordinate ranges of mountains, lying at a considerable elevation, and containing a large number of lakes, of which the Klamath were the most important. This basin was drained through the canons of Pit river, the largest tributary of the Sacramento, which, like the Klamath river, had forced its way through the mountain ranges which lay between the basin and the sea; Pit River flowing through an impassable canon nearly an hundred miles in length. The Klamath basin was once to a much greater extent covered by water than now; and, before it was so perfectly drained as now, its waters deposited a variety of strata, some of which were as white and fine as chalk, though having a very different composition.

He said further, that the basin or plateau of the Des Chutes was not separated by any barrier from that of the Klamath lakes, and exhibited all its peculiar features still more strongly marked. The Des Chutes basin was a plateau lying between the Cascades and the Blue Mountains, and, with the Klamath basin, belonged, from its topography, geology, fauna, flora, and climate, to the great central basin. Like the Klamath basin it was once covered with water—was a lake drained by the Columbia, as now, but not so perfectly drained. The Columbia had been gradually deepening its bed. The Des Chutes lake, as it then was, had deposited sediments to the depth of 2000 feet or more, for the streams which now traverse it have cut canons in this plateau to that depth. These sediments were covered by a floor of trap, which had been poured evenly over the whole surface—which had not been subsequently disturbed, and when broken open, exhibited a columnar structure—the columns being quite perpendicular, and sometimes one hundred feet in height. Below the trap was a series of strata exhibiting all possible varieties of volcanic tufa, some very fine and chalky, others coarser; and the different layers, which were from two to ten feet in thickness, and perfectly parallel, were coloured with all the hues of the rainbow—red, green, yellow, blue, orange, pink, white, &c., and as highly coloured as a geological chart for a lecture-room. It had often happened to him, travelling over this plateau, to come suddenly and without any warning to the brink of one of these canons two thousand feet deep, at the bottom of which a stream was flowing.

The Cascade Mountains, he said, were not a simple chain, but a broad belt of mountain peaks, sometimes fifty miles or more in width, many of the summits being covered with perpetual snow, the passes being generally about 7000 feet in height. He had found extensive proofs of the existence, at a former period, of glaciers capping the Cascade range, and extending far below the present limit of perpetual snow. The Cascade range was eminently volcanic, abounding in craters, lava fields, and congealed lava streams, all as fresh and ragged as though just poured out from some volcano; indeed, Mount Hood and Mount St Helens may still be considered as active volcanoes, giving off gases and steam continually, and within a a few years have emitted showers of ashes.

Professor Newberry's theory of the excavation and filling of the valleys of California and Oregon was, that at one time, probably at a period corresponding with that of the drift in the Eastern States, all that portion of the continent was raised to such an altitude as to produce a degree of cold which covered the mountains and filled the valleys with ice. By this ice the surfaces of rocks were worn down, and the marks of glacial action which now abound produced. The valleys were excavated in part by this process. As the continent was depressed the valleys were occupied by water, in which the ashes from ranges of active volcanoes were discharged, and arranged in strata of sediment.—(*Wells' Annual.*)

On the Discovery of Volcanic Cinders at the bottom of the Atlantic.—The specimens from the bottom of the Atlantic obtained by the U. S. steamer Arctic, in her recent deep-sea sounding expedition, between the coasts of Newfoundland and Ireland, having been submitted to microscopical examination by Professor Bailey of West Point, show evidence of the existence of a volcanic deposit on certain portions of the ocean-bed. In reference to these Professor Bailey says :—The occurrence of what appear to be volcanic products in the bed of the ocean for a distance of about twenty-two degrees of longitude, or about 1000 miles, is an extraordinary fact, and one which deserves careful scrutiny. That any one familiar with the microscopic appearance of volcanic ashes, &c., would pronounce these matters to be of volcanic origin I have no doubt. These volcanic products consists of pumice, obsidian, crystals of horneblende—single and in groups—and other igneous products penetrated by crystals. As, however, the ingenious suggestion was made to me that these igneous products might be derived from the fires of the ocean steamers, along or near whose pathway these soundings were made, it became important that these furnace products should also be studied. An examination was accordingly made of specimens of such matters as are thrown overboard from the ashpits of the steamers Asia and Baltic. Careful examination of the specimens showed that they contained a group of products which could not possibly be confounded with the supposed volcanic matters. In fact, there was no relation between the two classes of bodies, except that both were evidently the results of intense heat upon different mineral matters. Among the furnace products of the steamer Baltic were numerous single and aggregated glass spheres of minute, or even microscopic size, which, if they should ever be found in the ocean soundings, would be very puzzling without this clue to their origin. The question of the original source of these volcanic products is one of great interest. How far these plutonic tallies may have travelled, and in what direction—whether from the Azores, the Mediterranean, or from Iceland—involves a study of currents and an examination of soundings which have yet to be made.—(*Wells' Annual.*)

Deep-Sea Soundings in the Arctic Ocean.—From a recent report of Lieutenant Maury to the Secretary of the Navy, we derive the following extract relative to some observations made last year by Commodore Rodgers, inthe U. S. ship Vincennes, on the temperature and specific gravity of the water at the surface, midway, and at the bottom of the Arctic Ocean. These observations are highly interesting. He passed up through Behring's Straits into that sea during the summer of 1855, and, though he remained in it but a few days, he availed himself of the opportunity to try the temperature and specific gravity of the water at various depths and places; and his observations show uniformly this arrangement or stratification in the fluid mass of that ocean—warm and light water on top, cold water in the middle, and warm and heavy water at the bottom. These observations, if extended, would go far towards the final settlement of the question of an open sea in the Arctic Ocean. It is likely that this warm water went in as an under current; that though warmer it was salter, and for that reason it was heavier. It was made salter, we conjecture, by evaporation; and while it was subjected to this process it was in some latitude where it received heat while it was giving off fresh water vapour. This substratum of heavy water was therefore probably within the tropics and at the surface when it received its warmth. Water. we know, is transported to great distances by the under currents, of the sea without changing its temperature, but a few degrees by the way. Beneath the Gulf Stream, near the tropic of Cancer, and in the month of August, with the surface of the ocean above 80 degrees, the deep-sea thermometer of the Coast Survey reports a current of cold water only 3 degrees above the freezing point. That cold current, or the water that it bore, must certainly have come from the Polar regions.

We know of numerous currents flowing out of the Polar basin, and discharging immense volumes of water into the Atlantic; we know of but one surface current, and that a feeble one, around the North Cape, that goes into this basin. All these out-coming currents are salt-water currents; therefore we cannot look for their genesis to the rivers of hyperborean America, Europe, and Asia, and the precipitation of the Polar basin—for all the water from these sources is fresh water. The salt that these upper currents bring out is sea-salt; hence we should be forced to conclude, were there no other evidence to warrant the conclusion, that there must be one or more under-currents of salt and heavy water flowing into the Arctic basin. A considerable body of water at the temperature of 40 degrees rising to the surface there—as come to the surface it must, in order to supply the out-going upper currents—would tend mightily to mitigate the severe cold of those hyperborean regions.

This discovery of Rodgers furnishes the only link that seems to have been wanting in the chain of reasoning to complete from known facts the theory of an open water in the Arctic ocean; and this discovery, taken in connection with what northern voyagers tell us concerning the migration of animals in those regions; with what Dr Kane saw and De Haven says; with the fact that harpoons fastened in whales on the shores of Greenland have been taken out of whales along the shores of Kamtschatka and Japan—these facts, taken in connection with the discovery which my own researches have fully developed, that the right whale of Greenland and the right whale of the North Pacific are the same fish, and that to it the torrid zone is as a sea of flame which it cannot pass; I say these facts, linked together, and taken in connection with other facts and circumstances, seem to form a chain of faultless circumstantial evidence, showing the existence of an open water in the Polar basin.—(*Wells' Annual.*)

On the Gulf Stream and its Deposits.—When the stream, in sweeping round the point of Florida, had parted with so much of its sediment as to bring the bottom within 60 or 70 feet of the surface, it became possible for the coral to exist, provided it could find water of sufficient purity. This would be the case at any point so far from the shore as to be beyond the influence of the surf's disturbance of the mud deposited along the coast. As the bottom formed by a deposit is necessarily situated on a slope, the coral would find a line parallel to the shore, along which none of the conditions of its existence would be wanting. This line would be that of a reef. Did not the island of Cuba interpose, this extension of Florida might go on indefinitely; but as the passage narrows, the force of the current necessarily increases, and there is therefore no hope that in this manner Cuba will be annexed. The laws regulating the deposition of sediment also afford an explanation of the long parallel ridges on the sea-bottom of the coast of South Carolina, in the bed of the Gulf Stream. Suppose that two or three submerged peaks, in the line of the Bahama Islands, stand within the stream. Behind these peaks there must be still waters, or at least an eddy. Here matter will be deposited by the waters, and this will in turn offer an obstacle which will continue to cause the effect further and further away from the original point. Again, while the Gulf Stream is moving in a curve around the point of Florida, nearly all its deposits will be made on the river side of the curve, that is upon this point; but after passing into the open sea, it takes a straight course and begins to deposit on both sides alike. Hence, by this theory, the origin of the Bahama Banks. Another very curious result of all this reasoning remains to be mentioned. As the limits of a channel narrow, the current necessarily increases its velocity. The heat of a warm current is therefore retained to a far greater distance from the point of departure. It is well known that the Gulf Stream affects favourably the climate of the north-western portions of Europe. There is nothing then absurd in the idea that during the decrease of the breadth of the Gulf Stream between Cuba and the main land opposite, a decrease of hundreds of miles, the temperature of the water carried across the ocean to the coasts of Ireland, Scotland, and Norway, has been constantly rising, and that from this cause an increasing amelioration of the climate of that part of the eastern continent has resulted.

MISCELLANEOUS.

Present Annual Production of Iron.—Mr Hewitt of New York, in a paper recently presented to the Geographical and Statistical Society, furnished the following memoranda respecting the production and manufacture of iron. Cast iron can only be traced back to the 13th century. Previously, the ore and charcoal were placed in alternate layers in a rude oven, and there smelted by a blast injected by a bellows worked by hand. Even so late as 1740 the total annual product of England was but 17,350 tons, made by 59 furnaces, at the rate of 294 tons per annum to each furnace—say one ton per furnace for each working day. Mr Hewitt estimates the entire annual product of Europe at that time at 100,000 tons, 60,000 of which were made in Sweden and Russia, and one-half of this quantity exported to England. The total consumption of iron in England at that day (only 116 years ago, or since the birth of some persons yet living) was not 15 pounds per head per annum, and that of all Europe but *two* pounds per head. The whole human race did not then annually require or produce so much as *one* pound of iron per head. Now Mr Hewitt produces data showing an annual production of *seventeen* pounds per head for the whole human family, or seven millions of tons in the aggregate, of which Great Britain produces rather more than one-half, and consumes at least one-fourth. The total product of 1856 is estimated by Mr Hewitt, from imperfect data, as follows:—

	Tons.		Tons.
Great Britain	3,585,000	United States	1,000,000
France	650,000	Prussia	600,000
Belgium	255,000	Germany (bal. of)	200,000
Russia	300,000	Austria	200,000
Sweden and Norway	179,500	Spain	27,000
Italy and Elba	72,000	Denmark, &c.	20,000
Total	6,889,000 tons.		

Asia, Africa, and America outside of the United States, may possibly raise this aggregate to 7,000,000 tons.

The annual production and consumption of the several countries is estimated as follows:

	Produce per head, lbs.	Consume per head, lbs.
Great Britain	287	144
United States	84	117
Belgium	136	70
France	40	60
Sweden and Norway	92	30
Germany, including Prussia	50	50
Austria	12¼	15
Russia	10	10
Switzerland	—	22
Spain	4¼	5

The rest of the world too little to be computed.

The intimate relations of iron to industrial progress and efficiency, as exhibited by this table, need here only be suggested.

Height of the Himalayas.—It appears from a late survey made of the Himalaya range, by Colonel Waugh, that the Khanchinjinga, which has been hitherto supposed to be the highest summit, is in fact not so—a higher mountain having been discovered, situated between Katamandoo and Khanchinjinga. This last named is 28,156 feet above the level of the sea; but the new summit reaches the enormous height of 29,002 feet. It has been proposed to call this Mount Everest, after a former surveyor-general of India.

New Form of Telescope.—At the American Association for the Promotion of Science, Mr Alvan Clarke, of Cambridge, gave a description of a new instrument of his own invention, for measuring the distance apart of stars too distant to be brought into the field of view of a telescope. Within a year from the first thought of the instrument entering his mind, he had built a telescope of six inches aperture, and 103 inches focal length, mounted it equatorially, governing its motion by Bond's spring-governor clock, provided the two eye-pieces, and as a substitute for a filar-micrometer, arranged a mode of using pieces of glass ruled with a ruling machine. Experiments have demonstrated the feasibility of using the two eye-pieces in this way, and of obtaining by them very accurate measures of the distances of stars, which are from three to one hundred minutes of space apart. The success of the instrument was, however, greatly due to the spring-governor which keeps each star upon the wire accurately bisected.

Mr Yarrell's Library.—In our last number we had occasion to notice the decease of an old and esteemed friend, William Yarrell. Leaving this world without having any one who would carry out and reciprocate his own pursuits, his comparatively small but peculiar library was disposed of at Stevens' sale-rooms on 13th, 14th, and 15th of November. The number of the whole lots for the three days only amounted to 772, but the sale did not conclude until past 5 on Saturday evening. Many of the books brought high prices. The following are those of a few, which in after days may be a curious record of the value and estimation of some works. Doubtless some were purchased as memorials of an old friend and companion.

Macgillivray's Natural History of Dee-Side and Braemar, privately printed for H.R.H. Prince Albert, £7; Bewick's British Birds, 1st edition, £5, 10s.; Walton and Cotton's Complete Angler, £9, 10s.; Forbes and Henley's British Mollusca, £12; Yarrell's British Birds, 3 vols., copies sold from £4, 4s. to £10, 10s., one copy with "Bewick's cuts" introduced, £21; Alder and Hancock's Monog. Brit. Nud. Moll. (Royal Society), £6; Owen's Odontography, £9, 15; Gould's Birds of Europe £91; Gould's Birds of Australia £79, (bought up by Author, work being out of print).

METEOROLOGY.

To the Editors of the Edinburgh Philosophical Journal.

GENTLEMEN,—As one of the first fruits of the Meteorological inquiries in which I have been engaged during the past year, I send you the Rainfall at 37 stations over Scotland, arranged so as to exhibit the amount at each station during every month of the year 1856. It is right to mention, that no selection of stations has been made, but that every station is included from which perfect returns were received for the twelve months.

It will be seen from this table that the average fall of rain over Scotland during the year 1856 amounted to a mean depth of 36·96 inches—say 37 inches. This, according to our present knowledge, derived from imperfect and partial data, would seem to be a very large amount; but as we have no returns equally extensive to compare with, we must suspend our judgment on this point.

The fall of rain during September was excessive, particularly on the eastern half of the island, and sufficiently accounts for the greater amount of damage sustained by the crops on that, than on the western side of Scotland.

It is instructive to note, that if we select from this table the most western stations, and compare them with some of the eastern stations, we shall find that the difference between the fall of rain on the eastern and western side of the island was quite immaterial. Thus five selected stations, on or near the west coast, gave a mean depth of 37·78 inches of rain;

while seven stations on or near the east coast gave a mean depth of 37·11 inches of rain. The position of the station in reference to the hills and mountains seems to have much more important bearings on the quantity of rain deposited, than the mere circumstance of the station being on the eastern or western side of the island. Thus at twelve stations, which may be called midland, the mean fall of rain greatly exceeded that of either east or west coast stations, amounting to a mean depth of 44·23 inches.

From directing attention to these facts, it is not intended to be stated that anything like satisfactory conclusions as to the general distribution of rain over the country could be deduced from one year's observations: But as much misconception at present seems to exist relative to the comparative depth of rain which falls on the eastern and western side of the island, and the influence of the hills on the fall at such stations seems to have been somewhat overlooked, it was deemed right to direct attention to the subject, and at the same time publish the table in full, that every one may have it in his power to study the facts, and deduce his own conclusions.—I am, Gentlemen, your most obedient servant,

JAMES STARK, M.D.

FALL OF RAIN AT THIRTY-SEVEN STATIONS IN SCOTLAND, DURING EACH MONTH OF THE YEAR 1856.

1856.	Jan.	Feb.	Mar	Apr.	May	Jun.	July	Aug	Sept	Oct.	Nov.	Dec.	Year.
Sandwick,.........	2·33	2·42	0·34	0·34	0·89	2·36	3·36	1·40	3·18	1·01	4·61	5·17	27·41
Galston	1·20	1·60	0·60	0·20	0·80	4·80	5·70	2·20	2·70	0·40	4·20	6·30	30·70
Stornoway, ...	2·06	3·62	0·17	1·59	0·97	6·13	5·85	2·26	2·40	1·43	3·71	5·50	35·69
Culloden,.........	1·97	2·48	0·12	2·74	2·58	3·13	2·37	1·63	5·14	0·49	1·74	1·66	26·05
Elgin, ...	1·77	1·35	0·27	3·40	1·81	2·89	2·89	1·57	4·31	1·40	3·17	2·14	26·97
Castle Newe......	1·87	2·21	0·22	5·11	3·19	1·92	4·10	2·35	8·91	1·13	6·24	2·56	39·82
Fettercairn	2·80	2·55	0·11	3·70	1·35	1·40	1·40	2·20	3·80	1·00	1·10	1·90	23·31
Strachan	2·89	3·55	0·12	5·40	1·96	2·84	2·74	2·53	6·90	1·33	2·67	2·13	35·06
Barry	4·17	4·03	0·01	3·22	3·84	4·01	2·48	4·21	7·00	1·27	1·34	2·58	38·16
Kettins	3·21	4·28	0·29	3·40	2·62	3·72	2·48	4·60	6·98	1·38	1·91	3·30	38·17
Arbroath	3·03	2·78	0·12	3·09	2·91	3·20	2·12	3·78	5·43	1·53	2·02	2·25	32·26
Perth, ...	1·86	4·08	0·19	2·18	2·63	3·68	1·98	5·08	5·62	1·40	1·04	3·79	33·49
Anstruther	2·22	2·59	0·08	2·20	2·46	3·95	1·86	5·10	3·78	1·53	0·95	3·25	29·97
Alloa...............	2·40	4.85	0·20	1·30	3·07	2·97	2·10	4·20	3·12	1·12	0·70	4·10	30·13
Callton Mor	2·18	4·00	0·10	2·17	2·92	6·50	4·16	3·68	2·57	3·23	2·64	6·68	40·83
Greenock	3·90	6·20	0·80	4·10	4·20	7·30	2·55	4·80	3·15	3·22	2·70	7·65	50·57
Edinburgh	2·29	2·01	0·11	1·56	2·61	3·12	1·81	3·12	4·66	0·55	0·47	2·63	24·94
Glencorse	3·05	2·85	0·10	3·55	3·65	5·15	2·40	4·65	7·45	1·35	1·40	5·20	40·80
Swanston	2·87	2·70	0·09	2·90	4·65	4·30	2·20	4·25	7·10	1·80	1·40	4·50	38·76
Harlaw	2·68	3·10	0·11	3·20	4·12	4·20	2·38	4·41	8·20	1·30	0·90	4·40	39·00
Colzium	3·24	3·94	0·11	2·73	4·21	4·84	3·20	4·76	8·56	1·59	1·21	7·50	45·89
East Linton......	3·00	2·60	0·10	2·50	3·00	4·40	2·10	3·85	6·90	1·00	1·50	4·00	34·95
Thurston	3·80	5·85	0·01	1·20	2·80	5·90	0·80	5·40	7·70	1·20	0·90	1·60	37·16
Yester	2·65	3·70	0·40	2·00	4·65	6·80	1·40	3·35	8·05	2·80	1·90	4·65	42·35
Thirlstane	1·00	1·35	0·50	1·59	3·00	2·68	1·93	4·18	7·20	1·30	0·80	2·65	28·18
Milne Graden ...	0·70	1·30	0·10	2·20	3·60	3·00	2·60	3·00	4·70	0·30	1·10	3·20	25·80
Kirkpatrick......	3·20	5·00	0·05	2·75	2·50	4·72	2·40	4·30	3·40	2·55	0·80	8·30	39·97
Dumfries	2·80	2·86	0·94	2·35	2·51	3·51	1·51	4·65	2·43	2·48	1·03	4·04	31·11
Thornhill	3·40	3·70	1·50	2·60	2·90	4·00	2·20	4·40	3·10	3·10	0·90	5·70	37·50
Wallacehall......	2·50	3·50	1·10	2·10	2·00	3·40	2·00	3·50	2·20	2·30	0·70	5·90	31·20
Penpont	3·20	3·90	0·70	2·10	3·10	5·10	1·70	4·50	2·10	2·70	1·50	6·10	36·70
Keir	4·30	5·20	1·30	3·00	3·10	5·30	2·00	4·70	2·70	3·20	1·75	6·50	43·05
Auchenbrack ...	5·55	4·65	0·45	3·00	4·40	6·30	3·00	5·65	1·55	3·20	2·30	8·10	48·15
Hastings-hall ...	5·00	6·00	1·40	3·90	5·50	6·40	3·30	5·30	2·50	4·30	2·30	10·10	56·00
Kirkconnell	2·50	3·70	0·40	3·50	3·30	5·30	2·40	5·60	3·00	3·40	4·20	5·60	42·90
Sanquhar	3·00	4·30	0·30	2·80	3·30	4·20	2·50	4·70	3·60	2·20	2·50	6·40	39·80
Wanlockhead ...	5·10	6·55	0·10	4·10	2·65	8·00	5·70	8·15	4·90	5·15	2·90	11·50	64·80
MEAN,	2·86	3·55	3·37	2·69	2·96	4·36	2·64	4·00	4·79	1·91	1·98	4·85	36·96

ABSTRACT OF THE METEOROLOGICAL REGISTER FOR 1856,

Kept at Arbroath, by **Alexander Brown**, Honorary Member of the Literary and Philosophical Society, St Andrews; and Observer for the British and Scottish Meteorological Societies.

Latitude 56° 34′ N. Longitude 2° 35′ W. Distance from the Sea, ⅜ths of a Mile.
Height of the Barometer above the Sea, 80 feet; height of the Thermometer from the ground, 11 feet, and of the Rain-Gauge, 2 feet.
The number of "Rainy Days" includes those days on which snow or hail fell.

1856.	BAROMETER.		THERMOMETER.							Days Ther. below 32°.	Rain in Inches.	HYGROMETER.		Fair Days.	Rainy Days.	WINDS, AT 8¼ A.M.									
	Corrected to 32°, and reduced to sea-level.		8¼ A.M.	7¾ P.M.	Mean.	Mean Max.	Mean Min.	Mean.	Spring Water.			Mean Dew Point.*	Degree of Humidity (complete Sat. 1·000).			N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.	Total.
	8¼h. A.M.	10h. P.M.																							
January	29·45	29·47	33°·8	33°·6	33°·4	38°·0	30°·0	34°·0	46°·0	21	3·030	29°·8	0·885	18	13	6	—	4	6	3	1	3	6	2	31
February	29·87	29·88	37·0	38·7	37·8	44·3	33·7	39·0	46·0	12	2·780	32·0	·839	16	13	2	—	5	3	1	4	5	6	3	29
March	30·21	30·19	37·7	38·0	37·9	46·3	32·1	39·2	45·7	18	0·121	30·9	·785	26	5	6	2	6	1	—	1	5	9	1	31
April	29·71	29·70	43·2	41·6	42·4	50·3	35·9	43·1	46·0	6	3·094	37·5	·827	15	15	4	1	7	4	3	2	2	4	3	30
May	29·85	29·84	46·5	45·3	45·9	53·7	38·4	46·1	46·5	2	2·910	39·2	·775	18	13	8	6	11	2	2	—	—	2	—	31
June	29·86	29·86	55·2	53·8	54·5	61·5	44·6	53·1	48·0	—	3·199	47·8	·773	13	17	2	2	2	2	1	2	17	2	—	30
July	29·86	29·86	58·2	57·0	57·6	66·6	46·2	56·4	48·5	—	2·119	51·1	·788	15	16	1	—	2	3	2	6	7	6	4	31
August	29·93	29·92	56·4	54·8	55·6	64·6	47·6	56·1	49·0	—	3·783	49·6	·770	19	12	6	3	5	3	4	—	1	6	3	31
September	29·82	29·81	51·5	50·0	50·7	57·3	43·7	50·5	49·5	—	5·431	44·5	·788	17	13	3	3	1	4	2	2	6	6	3	30
October	30·04	30·04	47·7	47·7	47·7	54·9	42·1	48·5	49·5	—	1·535	44·1	·916	20	11	6	—	—	4	3	3	3	4	8	31
November	29·95	29·84	36·8	37·4	37·1	42·7	33·1	37·9	48·7	18	2·021	32·4	·885	18	12	6	—	1	1	1	—	8	10	3	30
December	29·54	29·52	36·0	36·4	36·2	41·0	31·3	36·1	47·5	17	2·251	33·0	·900	19	12	3	1	—	2	1	1	15	8	—	31
Mean	29·84	29·83	44·9	44·5	44·7	51·8	38·2	45·0	47·5	94	32·274	39·3	0·825	214	152	53	18	44	35	23	22	72	69	30	366
Do. 1855	29·81	29·81	44·2	43·9	44·1	51·8	36·8	44·3	47·2	142	21·026	37·1	0·793	231	134	62	19	25	41	42	35	41	69	31	365

Barometer at 8¼ A.M. was highest on 3d March, 30·67. Wind N.W.
Do. do. was lowest on 24th January, 28·53. Wind S.E.
Do. at 10 P.M. was highest on 2d March, 30·65. Wind N.W.
Do. do. was lowest on 24th January, 28·49. Wind S.E.
Thermometer at 8¼ A.M. was highest on 1st August, 69°. Wind S.
Do. do. was lowest on 3d December, 16°. Wind N.W.
Do. at 7¾ P.M. was highest on 25th June and 1st Aug., 69°. Wind W. & S.
Do do. was lowest on 3d December, 19°. Wind N.W.
Thermometer in night, highest, 30th July, 56°; lowest, 2d and 3d December, 16°.
Thermometer in day, highest, 26th June, 77°; lowest, 3d December, 25°.
Coldest day, 3d December, when average of Thermometer was 20½° for day and night.
Hottest day, 1st August, when average of Thermometer was 65½° for day and night.
Coldest month of the year, January; hottest, August.
Wettest month of the year, August; driest, March.
Mean temperature of the year, 44·85 degrees.
Mean temperature of thirteen years, 45·532 degrees.

For ten years the average daily temperature at 8¼ A.M., at 7¾ P.M., and the mean of the daily extremes, are as follows, viz.:—

	8¼ A.M.	7¾ P.M.	Mean of Extremes.
1847	45°·6	44°·7	45°·9
1848	45·1	44·4	45·0
1849	45·1	44·4	44·7
1850	45·5	44·9	45·5
1851	45·7	45·4	46·3
1852	46·0	45·9	46·2
1853	45·4	44·9	45·6
1854	46·3	46·4	46·3
1855	44·2	43·9	44·3
1856	44·9	44·5	45·0

The average temperature of the six months of chief vegetation, viz., those from April to September inclusive—for nine years, is as follows:—

1848	51°·7	1851	52°·0	1854	53°·5
1849	52·2	1852	53·0	1855	52·1
1850	51·7	1853	53·4	1856	50·9

---

* The dew-point thus found is obtained from observations of the Wet and Dry Bulb Thermometers, and deduced by Mr Glaisher's Hygrometrical Tables. The observations of the Wet and Dry Bulb Thermometers are made daily at 8¼ A.M. The times of observation of the instruments stated in the Table are Greenwich mean time.

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No. X. for April 1857 *page* 351, Entomology, vicinity of Melbourne, Australia, *read* to John Jones, Esq., Gloucester, by P. Edwards, Esq. of Ross, instead of as it is printed.

Same Number, *page* 380, in Kidderminster Deposits, *for* Eurypterus *read* Pteraspis.

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THE

EDINBURGH NEW

PHILOSOPHICAL JOURNAL.

Mountain Climates considered in a Medical Point of View.

By Dr H. C. LOMBARD.*

WHAT is the effect of a mountain residence on the course of diseases? Such is the question which has often presented itself to me in the course of my medical practice, and on which it has been my wish to collect a few observations, very incomplete it is true, but at the same time very little known. I have been unable, indeed, to find in medical literature any particular work devoted to this subject, and it has appeared to me that some benefit would arise from supplying this want in the science.

In speaking of a residence on elevated situations, the first question that presents itself is, what is a mountain climate, and what are its meteorological characteristics? In order to answer this question I examined works on Meteorology, but not finding there the desired information, I applied to Professor Plantamour, who has had the kindness to furnish me with very valuable particulars.

In the second place, I have availed myself of various sources, in order to study the physiological and pathological modifications impressed on living bodies by a residence on heights.

With regard to influences of a purely physiological nature, I have found all the materials requisite for answering the question in a recent work by Dr Meyer-Ahrens of Zurich

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* From the Bibliothèque Universelle de Genève.

The pathological influences of mountain climates, being a subject greatly more complicated, I have found it necessary to undertake numerous researches in reference to them.

On this point, the works of Dr von Tschudi on the diseases usually met with in the very elevated regions of our globe, have furnished me with very valuable information. In regard to countries of inferior elevation to Peru or Bolivia, I have obtained very complete documents, for which I am indebted to the bibliographical researches kindly made for me by Dr Appia. But as there are, notwithstanding, many questions which cannot be answered by means of the works that have been published on this subject, I have availed myself of the knowledge of many of my colleagues, who have readily replied to my inquiries as to the result of their observations on the diseases most extensively diffused among the mountaineers of different countries.

Professor Bertrand of Grenoble, and Dr Albert of Briançon, have made me acquainted with the predominating character of the morbid affections which prevail among the Alps of Dauphiny. Professor Savoyen of Moutiers, and Dr Michon of Chamounix, have rendered me a like service in regard to Tarentaise and the valley of Chamounix. Many practitioners in our vicinity have conferred a similar favour with reference to the diseases most prevalent in the Jura and adjoining districts of Savoy. Lastly, my excellent friend, Dr Lebert, who practised for a long period in the neighbourhood of Bex and Saint Maurice, before being appointed Professor at Zurich, has communicated to me a work in manuscript from which I have derived most valuable information on the subject before us. With the advantage of all these documents, for the most part unpublished, I have been enabled to trace the outlines of the picture of *Alpestrine Pathology*.

Proceeding, after this, to examine the effects produced by a residence among mountains, both in the case of invalids, and of healthy individuals, I have been led to draw some practical conclusions as to the maladies which may be combated by this means, and at the same time as to such as are aggravated by the bracing atmosphere of high lands.

Lastly, after having reviewed the different alpine localities which may be selected for the purpose in question, and explained the hygienic precautions necessary for success in a mountain residence, I have come to some practical conclusions as to making the best choice between different localities, keeping in view the particular disorder which we wish to counteract.

It is thus seen that the medical history of mountain climates touches on many questions in Meteorology, Geography, Physiology, and Pathology. In order to discuss it with advantage, therefore, a great number of facts must be brought under our observation, and even after this has been done, I can regard this work only as the commencement of an investigation, which others, with fuller information, may turn to better account, and render more useful to science than I have succeeded in doing.

I.—*What are the Meteorological characters of Mountain Climates?*

If we compare the great plains of Europe with the countries in the vicinity of the high Alps, we may assign the name of mountain climate to that of the principal valleys of Switzerland, the Tyrol, or the Pyrenees. It is not, in fact, necessary that a country should be in the immediate vicinity of mountains in order to have its climate modified by the presence of snow, the frequency of fogs, and the intensity of aerial currents, for we can recognise even in the climate of our valley some of the characters peculiar to the atmosphere of mountains. We can observe the frequent falls of rain in the districts adjoining the Jura, the accumulation of fogs formed on the heights, and which the north wind gathers in masses over our heads, as they are arrested by Mount Sion in front, the Salève on the one side, and the Jura on the other. Lastly, we may observe the sudden sinking of the temperature when the rains of the plain are converted into snow on the summits of the surrounding mountains. All these meteorological circumstances may be considered as being, in some degree, characteristic of alpestrine climates, if we compare them with the plains of France, Germany, or Lombardy. But it is our wish to confine the subject which now engages us to more elevated localities, and direct attention chiefly to such as are situated at a height more or less considerable above the neighbouring valleys.

Even with this limitation, the question of the meteorological characters of mountain climates is not sufficiently simplified. For, in examining each locality, we must take into account not only the absolute elevation above the sea-level, but also the exposure; recollecting that no comparison can be instituted between the northern and southern declivity of a mountain chain; and that, owing to the disposition of the surrounding hills, two localities situated at the same height may possess an entirely different climate. Such is the case, for example, with Montreux, compared with other villages in the neighbourhood, which have not the same advantage of being completely sheltered from the north wind, and receiving the solar rays during great part of the day. Such, likewise, is the case with Mornex, which, from its position on the eastern and southern slope of the Little Salève, enjoys a very different climate from the surrounding villages, and in particular from Monnetier, whose temperature is much colder, to a degree altogether disproportionate to the difference of level between two localities so near each other.*

With these preliminary reservations, we may now proceed to consider the subject of mountain climates, taking as points of comparison, Geneva and the Hospice of St Bernard, the height of which, according to the recent measurement of Professor Plantamour, is 8230 feet above the level of the sea. Various considerations operate in favour of the choice of these two localities as terms of comparison. The first is, that at both of them numerous meteorological observations have been made according to the most approved method, and with the most trustworthy instruments, so that these two series of observations may be considered as admitting of the most rigorous comparison with each other. A second reason for the selection of the Hospice of St Bernard as a type of this kind of climate is, that it is the most elevated spot in

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* The height of Monnetier is 2335 feet; that of Mornex about 820 feet lower.

Europe permanently inhabited, and as such can present us with the most correct observations, and at the same time the most conspicuous features of alpestrine climates. Lastly, a consideration of the utmost importance, in my estimation, is the opinion of Professor Plantamour, who regards the comparison instituted between Geneva and the Hospice of St Bernard as admitting of being applied to all the mountains of the temperate zone, and as capable therefore of deciding the question with which we are occupied. This opinion M. Plantamour has confirmed by investigations, the result of which he has communicated to me in a manuscript note, from which I shall extract the principal conclusions.

"The difference between a mountain climate and that of a plain may be briefly stated as follows :—

"1st, *Temperature.*—This diminishes with the height. The decrease between Geneva and St Bernard is one centigrade degree for 616 feet of height; but, as the mean temperature of Geneva is lowered by the vicinity of the lake, this figure indicates a slower decrease than that generally observed in the temperate zone, that is, about one degree in 557 feet. The range of the diurnal variations is less at St Bernard than at Geneva. The maximum comes sooner, the minimum later.

"The range of annual variations diminishes as we ascend.

"2d, *Atmospheric Pressure.*—This diminishes with the height, which likewise tends to render the diurnal variations less extensive than in the plain, while the contrary is observed in the annual variations of the barometer.

"3d, *Humidity of the Air.*—The absolute quantity of vapour contained in the air naturally diminishes with the temperature. With regard to the relative humidity, or the degree of saturation, the annual mean does not present great differences in the two stations, while the monthly and diurnal variations are much smaller at St Bernard than at Geneva.

"4th, *Rain or Snow.*—Of these the annual quantity is one and a half, or twice greater at St Bernard than at Geneva, especially in winter.

"5th, *State of the Sky.*—There is little difference with regard to the state of the sky, on comparing it throughout the year in the two stations, but while the summer is the most cloudy season at Geneva, it is winter that is clearest at St Bernard."

From the observations just given, and also from the information contained in the works of meteorologists, we obtain the means of characterizing mountain climates, on comparing them with the neighbouring plains and localities which have the same exposure.

We may affirm that the air of mountains is colder the more elevated they are; but, at the same time, the temperature is more uniform, so that one is much less exposed than in the plain to those sudden variations which frequently take place in the course of a single day.

The atmospheric pressure diminishes with the height, and this difference in the weight sustained by the human body, gives rise to various phenomena to which we shall again recur when treating of the modifications produced on our organs by a residence in an alpestrine climate. At present we may merely mention the rapidity of evaporation, which increases with the diminution of atmospheric pressure. The higher, therefore, a locality is above the sea, the drier will be the air, and the more speedily will it extract moisture from the bodies exposed to it.

This last remark leads us to examine the question of the greater or less degree of dryness in the atmosphere of mountains.

There is, in the first place, a great diversity of opinion among meteorologists, as to the relative humidity or precise degree of saturation. Some, such as De Luc and De Saussure, infer, from their observations on Mont Blanc, that the air of high mountains is much drier than that of the plains. Others, such as Kæmtz and Bravais, have found the air on the Righi and Faulhorn sometimes drier and sometimes moister than in the plain.* Finally, Professor Plantamour has come to the conclusion, from a long series of observations made at Geneva and St Bernard, that if we consider the annual means, there is no very notable difference between the mountain and the plain. But if we compare the diurnal or monthly variations, we shall find a much greater degree of uniformity in the elevated situation. We thus definitely ascertain that the inhabitants of elevated regions are not subjected to those changes in the humidity of the atmosphere which are so frequent in lower countries.

---

* Cours complet de Meteorologie; translated by Ch. Martins. Paris, 1843.

Three circumstances should contribute to render the air drier on heights; *first*, the facility of evaporation under diminished atmospheric pressure; *secondly*, the frequency and intensity of aerial currents on the summits and sides of our Alps; *thirdly*, the power of the solar rays, which rapidly dry the earth and organized bodies. Exposure for a few minutes to the heat of the sun, in this rarefied air, is sufficient to dry the face, and cover the unprotected parts of the body with blisters, as we shall afterwards learn. At present we allude to these different phenomena only in as far as they are connected with the dryness of the air.

It is true that the difference of temperature in the different atmospheric strata causes the condensation of the vapours in elevated places; hence, in the latter, there is a more clouded sky, and more abundant rain, as we have seen in regard to St Bernard, where the quantity of rain and snow is nearly double that which falls at Geneva. But, as has been seen, a greater degree of humidity in high districts is not produced by this; and this is no doubt owing to the sloping position of most alpine localities, and the strength of the currents of air, which do not permit the moisture to obtain a lodgment in the soil. As the last property of the atmosphere of elevated regions, I may mention the absence of dew at sunset, a circumstance eminently favourable to invalids and such as are convalescent, as they may remain pretty late in the open air without apprehension of that sensation of damp chillness which is so dangerous in other places.

To recapitulate briefly what has been said; it may be affirmed that we find in elevated situations an atmosphere colder and more steady, both in regard to temperature and humidity, and also more frequently renewed, than in the adjoining plains. With such properties, mountain climates ought to possess great value to such as dread the heats of summer, who are tried by sudden thermometrical or hygrometrical changes, and who stand in need of a more vivifying air than that of the plains. We shall afterwards see where and in what manner the objects sought for may be best attained.

II.—*What is the Physiological and Pathological Influence of Mountain Climates?*

The differences of temperature and humidity which have been indicated between countries situated at different heights, present no character exclusively peculiar to them, and which may not likewise be found in other localities placed at the same level above the sea, although in different latitudes. Such, however, is not the case with atmospheric pressure, which can never have the same character at different heights. We may sometimes observe the barometer descend a certain number of millimetres, but we never notice differences like those which exist between Geneva and St Bernard, or between the sea-shore and the summit of the Righi or Mont Blanc. There exists, therefore, in mountain climates a new element of great importance, that is, a less degree of atmospheric pressure, and consequently air of less density, as well as a decrease in the quantity of oxygen necessary to sustain life by means of respiration. It is to these last two circumstances that we must ascribe, in a great measure, the phenomena observed on high mountains, and to which I wish for a short time to direct the attention of my readers.

On applying to physical science, we shall be informed that the entire weight of the atmosphere represents as many times 300 *kilogrammes* as there are square decimeters on the surface of our bodies; so that, according to the stature of different individuals, the total weight supported by our organs will vary between 15,000 and 20,000 *kilogrammes*. On leaving, therefore, a country more or less nearly on a level with the sea, in order to repair to a higher locality, our bodies will be subjected to less degree of pressure in proportion to the elevation. It is easy to understand what degree of disturbance our organs must undergo when the enormous weight which they habitually bore has been diminished by a sixth part, a quarter, or even a third, as has been observed on the Righi, St Bernard, and the top of Mont Blanc. And if we add to this diminution of pressure the no less important change which takes place in the density of the air, and consequently in the quantity of oxygen, we shall have little difficulty in accounting for the various disturbances which take place in the respiration, circulation, locomotion, and digestive functions, of those who have ascended the lofty peaks of our Alps, and made them for a time their place of abode.

In the appearance of the symptoms just spoken of, it is not easy to say what portion we are to ascribe to the diminished pressure, and the insufficient supply of oxygen. The respiration and circulation should be alike modified under these two influences, and ought to react on the muscular strength. On the other hand, as recent investigations have shown that it is owing to atmospheric pressure that the head of the thigh-bone is kept within the cotyloid cavity, it is evident that the diminished weight of the air must render the movements more difficult. We thus come to the conclusion, that the appearances produced in living bodies, when transported to great heights, are the result of the two meteorological facts in question—a diminished pressure, and a smaller quantity of oxygen.

After these preliminary remarks, bearing on certain theoretical questions necessary for understanding our subject, let us now proceed to consider the modifications in our organs, whether physiological or pathological, occasioned by a more or less prolonged residence among mountains.

With a view to facilitate the study of the phenomena observed in man and animals, we shall divide the localities which form the subject of our observation into two classes; those which are situated *above* 6560 *feet*, and which, for the sake of shortness, we shall call *Alpestrine climates*. We shall then describe the effects produced by *Alpine* or *sub-alpine* climates, that is, such as characterize localities situated *below* 6560 *feet*, and which contain the greater part of the villages or establishments to which patients are sent.

The investigations which follow present themselves under two very distinct aspects. It is found that some of the changes which take place under the influence of mountain climates extend no farther than to modify the play of our organs, without inducing serious or prolonged derangement, and may consequently be termed *Physiological*. Others, which may be nothing else than a continuation or aggravation of the former, exercise an action sufficiently powerful to give origin to some disease, and consequently fall under the domain of Pathology. Let us consider these twofold consequences of an abode in alpestrine and alpine climates.

§ 1. *Physiological and Pathological influence of Alpestrine Climates* (above 6560 feet).

The effects produced by the ascent of high mountains, or by a residence in the elevated regions of our globe, have been frequently studied, both among the Alps and Pyrenees, and also in the chain of the Andes, under circumstances which cannot be realized in Europe. Indeed, notwithstanding the important labours of De Saussure, Bravais, and Martins, on Mont Blanc, at a height of 15,744 feet; those of Desor and Agassiz, on the glaciers of the Aar, at a height of about 13,120 feet; it must be remembered that these observers could remain but a short time in regions so desolate and incapable of furnishing adequate shelter for a lengthened abode. But this is by no means the case in South America, where valleys and plateaux are to be met with in the chain of the Andes permanently inhabited, although their elevation is from 11,840 to 13,120 feet.* One of these, is particular, is the valley of Puna, where our countryman, Dr Tschudi,† resided for a long time, as well as in many other regions of the same nature. He informs us that, in Peru, they use the name *mal de puna* to indicate the effects produced by high situations on those who visit them, or live for a longer or shorter period upon them. The inhabitants of these elevated regions likewise call it *sorroche* or *mareo*. The last of these designations establishes a pretty correct comparison between sea-sickness and the influence of heights on the human body.

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* See the list of these various localities in the *Annuaire du Bureau des Longitudes*.

† Reiseskizzen in Perou. Sanct. Gallen, 1846.

A perfect identity has been found to exist among the effects produced on living bodies in whatever part of the world they have been observed, insomuch that all these facts may be united in a single view, and distinguished by the same name, *the mountain sickness* (*le mal de montagne*). This has been done by Dr Meyer-Ahrens of Zurich, in a work lately published at Leipsic.* Considering, with this author, the principal changes produced in our organs by the ascent of high mountains, or a residence in Alpestrine valleys, we shall pass successively in review those which arise in the functions of digestion, locomotion, circulation, respiration, and, finally, such as affect the nervous centres.

The digestive organs undergo considerable modification, indicated by an ardent thirst, with a desire for water and other cooling liquids, and an aversion to wine and other strong liquors. De Saussure, who has often experienced this sensation, has however remarked, that if this repugnance be overcome, the use of spirituous liquors, in moderate quantities, entails no disagreeable consequences, but on the contrary recruits the strength without causing intoxication; he has often observed that a draught which would inebriate in the plains no longer had that effect on the mountains. The appetite is sometimes increased, but for the most part it is destroyed altogether, and the distaste for food is so decided, that in trying to overcome it, nausea and even vomiting supervene. This I have myself experienced after having climbed, without stopping, from the foot to the summit of the Great Salève, which formed an ascent of nearly 3280 feet.

One of the effects of elevation is, that the muscular strength is weakened; the least exertion is attended with great fatigue, even in men of the greatest vigour. Beasts of burden lose their strength even more speedily than men; they become short of breath, and are obliged to stand at every step, and, if forced to continue their journey, they soon sink, and their carcases may be seen lying in the elevated passes of the Andes.

The circulation and respiration are obviously quicker than on the plain; the inspirations are deep and quick or gasping (*saccadées*); the heart beats forcibly, and often with quickness double that of its ordinary state. This was observed by Dr Meyer during his ascent of the Jungfrau. It must not, however, be supposed that this acceleration of the pulse is owing only to the muscular efforts occasioned by the ascent, since Dr Tschudi observed it in his own case, although he was on horseback. It was likewise remarked by Gay-Lussac and Biot, although they were motionless in a balloon, at the height of 8370 feet, the pulse of the one rising 22 beats, that of the other 32.

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* Die Bergkrankheit oder der Einfluss des Ersteigens grosser Höhen auf den thierischen Organismus; in 8vo, 1854.

The nervous system likewise presents some important symptoms, such as vertigo, somnolency, pains in the head, sometimes very severe; frequently, also, a complete and sudden prostration of strength, so as to render all movement impossible; a condition for which even fatigue can in no degree account, and which must be ascribed to a particular state of the nervous system. Some travellers have experienced a feeling of lightness, as if their bodies were no longer in immediate contact with the earth; others have felt a pressure from below upwards under the soles of the feet; often, also, hummings in the ear occur, and the motion of bubbles of air in the Eustachian tube.

Lastly, various other symptoms are observed depending on the dryness and rarefaction of the air, both of which are remarkably promoted by the evaporation. It is under this influence that the ardent thirst of which we have spoken is developed, and which is no doubt caused by the desiccation of the walls of the mouth and the air passages; chaps also make their appearance on the lips and other parts of the skin exposed to the action of the air.

Such is a view of the phenomena usually observed in man when transported to the higher regions of the globe. Animals also present various symptoms, which must not be passed over without notice.

The inhabitants of the Andes, who are of Spanish origin, have been desirous to carry with them their favourite amusement of bull fights into the high valleys of Bolivia, as, for example, to Paz, a town situate 12,234 feet above the level of the sea. But they found themselves quite unable to rouse the combative energies of these animals, now become gentle and peaceable; and, far from tearing each other, they became weak and breathless after a few frail efforts, and were seized with continual vomitings; a grievous disappointment to the spectators who, instead of the sanguinary struggle they expected, found themselves assisting at what may be called a medico-veterinary case.

Cats cannot live at an elevation above 13,000 feet; carried to this height, they invariably sink after being seized with very singular shocks of tetanus. At first they show only irregularity in their movements, as if affected with St Vitus's dance; but these shocks afterwards become more and more severe, they make prodigious leaps, as if they wished to scale the rocks or the walls of the houses; after these violent efforts, they fall exhausted with fatigue and die in convulsions.

Dogs bear up longer than cats, especially if they have been whelped in the country. Conveyed to these regions, they may continue to live there for one or more years, although seized with convulsive movements very like those observed in young dogs, when attacked with the dog-malady.

Rabbits can live at a great elevation, although it is asserted that they then become barren. Gallinaceous birds soon perish. Horses and mules, although they suffer much, at length become acclimated. A great number of them die from the effects of fatigue disproportionate to their muscular strength, in an atmosphere so rarefied as that we are now considering.

After having noticed the different symptoms which characterize the mountain sickness, it remains for us, before concluding, to say a few words on the circumstances which favour its development, its duration, and appropriate treatment.

The circumstances which appear to favour the development of this morbid affection in those who are seized with it, are, an unusual degree of fatness, a vigorous constitution predisposed to congestions, and birth in a flat country, which renders residence in a different region greatly more difficult. With regard to meteorological considerations—the dryness of the air appears to contribute to its development, as those affected suffer

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much less in rainy weather, or when the air is charged with moisture.

The various symptoms of the malady in question are not of equal duration. If they are caused by the ascent of a mountain they usually disappear with rest and return to the plain. If the stay on the heights has been prolonged for some time, most of the disturbances in the nervous system and digestive organs commonly disappear at the end of ten or twelve days. But lassitude and dyspnœa last for a longer time; a space of many months, sometimes even of some years, is necessary to make them completely disappear, particularly in those who come from a flat country.

Some travellers allege that a person is attacked by the mountain sickness only once; but this is not strictly correct, although in every case the first attack is always the most severe.

The most suitable treatment to counteract the symptoms in question consists, in the first place, of rest, and the use of some kind of spirits, when they have been occasioned merely by the fatigues of the ascent, as their influence, in that case, does not extend beyond a few hours or days. But when a prolonged visit has been made to the high regions, it is necessary to have recourse to a prophylactic treatment, and a rational use of medicine. Experience has shown that an aromatic infusion is an excellent preservative against the dyspnœa and vomiting. Tea appears to answer this purpose pretty well; but, among the Andes, great importance is attached to an infusion of the leaves of *Erythroxylon Coca.* The Indians always carry some of these with them, sometimes keeping them in their mouths, and sometimes making an infusion of them. Dr Tschudi found much advantage from them when he went to hunt in valleys between 10,000 and 13,000 feet above the sea. The inhabitants of the country likewise employ for the same purpose, and in the same manner, cloves of garlic, with which they rub their mouths and faces. By these means also they restore some degree of strength to the beasts of burden when they are short of breath and exhausted.

With regard to the rational treatment, it must depend on the form the malady assumes. If it is accompanied with faint-ing, paleness of countenance, and vomiting, it is necessary to have recourse to stimulants, which can then be taken in large doses without producing intoxication. But more frequently the disorder takes the form of inflammatory fever, with a tendency to cerebral or pulmonary congestions; an antiphlogistic treatment is accordingly for the most part recommended. It consists in one or repeated bloodlettings, in the use of fruits, acidulated and purgative draughts, such as cream of tartar and the pulp of tamarinds. Absolute rest in a darkened chamber, kept at a proper temperature, contributes equally to the cure.'

Besides the mountain sickness, such as it has been described, other morbid affections are likewise observed in the elevated districts of our globe, which we shall consider in succession, availing ourselves of the researches of various authors, and more especially of those of Dr Tschudi, who has published the result of his medical experience during his residence in Peru and Bolivia.*

One of the most striking features in the pathology of the higher districts, is the frequency and severity of every kind of hæmorrhage. Under the influence of diminished atmospheric pressure, and also in consequence of the dry and essentially tonic state of the air, we meet with frequent cases of hæmoptysis, epistaxis, hæmatemesis, and melænas, so severe as to cause death. In certain regions of Peru there occurs also a kind of purple hæmorrhage, characterized by pustules and boils, which sometimes terminate in suppuration, and sometimes permit the escape of a considerable quantity of blood; from one of these swellings Dr Tschudi has seen upwards of six pounds of pure blood issue. Along with these local symptoms fever supervenes, with cramps, pains in the joints, dysphagia, and great anxiety. This disease which has received the name of *veruga*, appears to be peculiar to Peru, and even to be confined to certain valleys where it prevails as an endemic.†

After hæmorrhages, inflammatory diseases are those which occur most generally in the high regions of which we are speaking. When they affect the nervous centres, they are as rapid in their progress as they are formidable in their consequences. The mountain sickness is often succeeded by an eruption very like urticaria, the phases of which ought to be watched with great care, for if the eruption become pale through cold or from any other want of caution, symptoms of cerebral excitement make their appearance, followed by stupor, coma, and death, in the course of a few hours. Dr Tschudi has often succeeded in arresting this formidable meningitis by means of copious bleedings, and the most energetic antiphlogistic treatment. There is another form of cerebral inflammation (meningitis) of very frequent occurrence among the Peruvian Indians as a consequence of alcoholic intoxication. This disorder is of a very formidable character, since scarcely one out of ten survives it, and it is so frequent that Dr Tschudi assigns to it one-third of the acute diseases of Puna. Nothing equals the rapidity of its progress, for from any excess in drinking, death often follows in the space of six or eight hours. These facts indicate a connection with the meningitis which prevails as an epidemic in the north of Europe, chiefly among soldiers, and which likewise causes death in a few hours.

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* Œsterreichische Med. Wochenschrift, 1846. Communicated by Dr Endlicher.

† Le Veruga. Maladie endémique dans le Perou. Archives der Physiologischen Heilkunde, Von Rosas, 1845.

With regard to pulmonary inflammations, they likewise partake of the acuteness and rapidity which have just been referred to, being almost always accompanied with pleuritic pains, so severe that even the apathetic Indian writhes like a worm under them, and betrays his suffering by the most significant gestures. But while the cerebral inflammations demand an active antiphlogistic treatment, this is not the case with the pleuro-pneumonia of Puna, which cannot be counteracted by bleeding. This method of treatment must indeed be avoided, not only as unavailing to effect a cure, but as even dangerous, for the patient not unfrequently sinks under the loss of blood. The stimulating treatment practised by the Indians ought therefore to be preferred, which consists in the use of strong doses of cayenne pepper (capsicum). Under this treatment copious transpirations take place, which are not long in removing the pulmonary symptoms. Inflammation of the inner parts of the mouth, of the larynx and bronchiæ, are also frequently observed in Puna.

The skin often becomes chapped, particularly in the parts exposed to the contact of the dry air of these regions; a prickling is felt in the face and hands, accompanied by a burning sensation; they then become covered with small cracks, which are followed by a pretty thick scurf. This disorder, which seizes new-comers, is known in Puna by the name of *choun.* It is easily cured by confining oneself for a considerable time to a close apartment, kept at a moderate temperature.

The other diseases of the skin met with in the same circumstances are erysipelas and urticaria.

Along with these, erysipelatous rednesses, and, under the influence of the dried air of these lofty regions, as well as the reflection of the light from the snow, very severe cases of ophthalmia make their appearance; six out of eight of Dr Tschudi's guides were attacked on the same day, and he himself escaped only by great precaution. He compares this ophthalmia with that of Egypt, and regards it as contagious by means of the purulent secretion which falls from the affected eyes. The Indians suffer much more from this disease than the Creoles, who are better acquainted with the means of guarding against it. If it be neglected, and the inflammation become very severe, it often ends in different kinds of chronic affections of the eyes, such as pannus, hæmophthalmia, hypopion, chemosis, ectropion and staphyloma, which often occasion total blindness.

(*To be continued.*)

Notes on the Food of some Fresh-Water Fishes, more particularly the Vendace and Trout. By W. Baird, M.D., F.L.S., &c.

When we consider the immense value of the fisheries of Great Britain, foreign and domestic (calculated some years ago by Mr Barrow* to produce not less than eight millions sterling annually), the investigation into the nature of the food of fishes is evidently one of no small importance. The difficulties attending upon a complete knowledge of the subject are no doubt many and great, especially with regard to the marine species, arising chiefly from our want of information as to their feeding-grounds; still something has been done by such men as Mr Yarrell and others, and any new observations tending to further our acquaintance with the food of these useful animals cannot fail to be of some value. The peculiar delicacy of flavour which distinguishes some of our fresh-water fishes has been long known to depend upon the nature of their food, though it is only in a few instances that the exact kind has been ascertained. Mr Yarrell, for instance, in his valuable work upon "British Fishes," informs us, upon the authority of the late Earl of Home, no ordinary observer, that the trout in Berwickshire differ very much, according to the locality in which they are found. The county of Berwick is divided into two districts, a hilly, mountainous region, and a flat, fertile plain. The two principal rivers rising in, and flowing through, the county, are the Blackadder and the Whitadder. This latter stream has its source at an elevation of 900 feet above the level of the sea, and flows over a very rocky and gravelly bed, whilst the former, the Blackadder, rises in deep mosses, and flows for one-half of its course through these mosses, and the other half through a rich and highly-cultivated district. The trout of the rapid, clear, and sparkling Whitadder are fine silvery fish, beautiful to look upon, but very inferior in taste to those of the dark, mossy Blackadder, abounding as it does in a greater variety and quantity of food, and which are of a dark colour, almost black, with bright orange fins. Two other smaller streams, the Eden and the Leet, traverse part of the same county, both flowing through a rich, loamy, and often marly soil, till they empty themselves into the Tweed. The trout of these little rivers, according to the late Lord Home, are of a good size, their bodies beautifully marked with bright red spots, and the sides and fins of an orange colour. The flesh is fully of a deeper red than that of the salmon, and almost as highly flavoured as that prince of fresh-water fishes. The trout of the Tweed, again, into which these two streams run, are very inferior, being in comparison both lean and ill-flavoured; and it is worthy of remark, that as soon as the fine rich trout of the dull and sluggish Eden and Leet enter the rapid, clear waters of the Tweed, they begin to lose their beauty and other good qualities; while, on the other hand, when the comparatively ill-flavoured trout of the Tweed ascend the Eden or the Leet, a change of colour is shortly observed to take place, and they soon assume the richer hues which distinguish those of the tributary streams. These differences in the quality of the trout arise, no doubt, from the nature of the food found in these various rivers. A direct experiment, to ascertain the value of different food upon the growth and development of trout was tried some years ago. For the details we are indebted to Mr Stoddart, who mentions the result in his "Art of Angling, as practised in Scotland." Several fish were taken and placed in three separate tanks of water. The trout in one of these were supplied with worms; those in another were supplied with live minnows; and those in the third were fed upon small dark water-flies. The trout which subsisted upon worms grew slowly, and had a lean appearance; those which were supplied with live minnows became much larger; whilst those which had flies alone given to them attained in a short time prodigious dimensions, weighing twice as much as both the others together. The great lake trout, *Salmo ferox*, is a coarse fish, and of an indifferent flavour. It is exceedingly voracious, and feeds principally upon other fishes smaller than itself, the stomachs of such specimens as have been examined having always been found gorged with fish. The Lochleven trout, *S. fario* var. *levenensis*, on the contrary, is a delicious fish, and, as I have stated in my work on the "British Entomostraca," its food has been found to consist in great part of these minute and delicate little crustaceans. The charr too, *Salmo salvelinus*, is another excellent flavoured fish; and we are informed by Sir W. Jardine, who has examined the stomachs of several, that their food consisted of minute entomostraca. To the kindness of this distinguished naturalist I was indebted last autumn for an opportunity of examining at leisure the nature of the food of another fresh-water fish, of exquisite delicacy and flavour. The Vendace, *Coregonus Willughbii*, Jardine, is a native of several of the small lochs that lie close to the town of Lochmaben in Dumfriesshire. The principal sheet of water is called the Castle Loch, as upon its bank is situated the old ruin known as Bruce's Castle. These fish are more abundant in that loch than in any of the others, and, according to the tradition of the place, were brought thither from the continent by Queen Mary. The vendace is an elegant little fish, of from four to ten inches in length, and of a pale greenish-brown colour on the upper parts, shading gradually into a clear and silvery white. The flesh is white and rich, of a delicate flavour, and highly esteemed as an article of food. It is so delicate, indeed, that it cannot be transported to any distance; and to be duly appreciated must be eaten on the spot. It is well known to sportsmen that this little fish had never been caught with an angle,* and that it could not be taken with any bait, the only way in which it is captured being by means of a net. Some years ago Dr Knox of Edinburgh examined the stomachs of one or two specimens, and found the contents to consist of minute entomostraca. In a paper on the food of the salmon, herring, and vendace, published in the "Transactions of the Royal Society of Edinburgh," in 1832, he mentioned this fact, and gave rough figures of two different species. Mr Yarrell also examined the contents of the stomachs of one or two specimens, and in his valuable work on "British Fishes" has reiterated Dr Knox's statement, and likewise figured the species. Both these gentlemen, however, had only specimens of vendace to examine which had been preserved in spirit, and accordingly the animals found in the stomachs were so much decomposed that their figures are not to be relied upon. Those of Dr Knox (at least one of them) are too indistinct to enable the species to be determined with precision, while those of Mr Yarrell appear to me to be merely copies of specimens figured by Jurine. Having had the pleasure, however, last year, of accompanying Sir W. Jardine to the genial meeting of the Vendace Club, which takes place annually on the 1st day of August, at the Castle Loch at Lochmaben, I had an opportunity of examining the stomachs of several specimens immediately upon their being taken from the water. The fish themselves were in excellent condition, fat, and evidently well fed; and, as I had an opportunity afterwards of testing at the Club dinner, exceedingly well-flavoured. The stomachs of those examined I found to be quite full, and containing myriads of a minute Entomostracan new to Great Britain, and which, I believe, has hitherto never been described, though in all probability it is one of those roughly figured by Dr Knox, in his paper alluded to. It belongs to the family *Daphniidæ*, and genus *Bosmina*; and I propose giving it the name of *B. Coregoni*. This genus was founded by me in 1845, in the "Berwickshire Naturalists' Club," to contain those species of the old genus *Daphnia*, which are characterized by having the superior antennæ long, and taking their origin from the extremity of the beak. Only one species has hitherto been described in Great Britain, *B. longirostris*, a minute creature, the anterior portion of the carapace of which terminates at the inferior angle in a sharp point or spine. The present species differs from it in being longer, having the superior antennæ much longer, the carapace greatly more rounded, and the inferior angle not terminating in the sharp spine.

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* Encyclopædia Britannica, Art. *Fisheries.*

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* An instance to the contrary has been mentioned by Dr Davy in the last number of this Journal, p. 348, where he states that he saw a specimen captured in one of the Cumberland lakes—"an uncommon incident."

As I have already mentioned, there were myriads of these little creatures in each stomach I opened; and upon examining the mouth of the vendace, a curious and very interesting structure is observable, which appears to be well adapted for enabling this fish to catch its prey. The mouth is small, and is unprovided with teeth, except a few small ones on the tongue, but upon opening it, and looking down, we observe that the arches of the gills are furnished on the inner side with numerous long processes, each of which is barbed on both sides, and project into the cavity of the mouth. Meeting those of the gill-arch on the opposite side, these barbed processes form a complete strainer, arresting even such minute creatures as these entomostraca. The fish, swimming through the midst of a dense shoal of these little crustaceans, must take in thousands along with the water which it imbibes, but instead of being expelled along with this water, which flows over the surface of the gill and escapes from under the gill-covers, they are arrested in their progress, and detained there till a quantity is collected sufficient to be swallowed.*

It is not my intention to enter into the history of the vendace; but a few remarks upon its geographical distribution may not be uninteresting. It was at one time believed to be exclusively confined to the Castle Loch of Lochmaben, but Sir William Jardine, in his paper in the "Journal of Geographical and Physical Science," has shown that this is not the case, as it is found in several of the other lochs in that neighbourhood. An allied species, locally known by the name of *Schelly*, has been long known to inhabit some of the lakes of Cumberland, and Dr Davy has recently proved that the Lochmaben fish is also found in Derwentwater.† This specimen was afterwards transmitted to Sir William Jardine, and in a letter received by me from him on the subject, he says, "I cannot make out a specific difference. At the same time, the fish is of a stouter make, and the proportions of the parts a little stronger. When looked at together there *is* a difference, but if placed before you singly, you would at once say they are one species." The same species, under the name of *Gwyniad*, is well known to exist also in Bala Lake, North Wales. Sir W. Jardine writes to me in the end of November last (1856) that he had then before him a fish from that locality, and upon comparing it with his own specimens of the Lochmaben vendace, he "durst not make it distinct, though very slight variations did exist in the outline of the opercula." In the same letter he adds, "this is an important fact, breaking down the very restricted locality, which I never had much faith in." "When the Lochmaben fish," he continued, "was shown to Agassiz, he said it was undoubtedly different from the Swiss species. I doubt this now, but have not been able to procure specimens." Sir John Richardson, in his valuable article "Ichthyology," in the last edition of the Encyclopædia Britannica, remarks that, according to M. Valenciennes, the

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* This curious structure was first pointed out to me by Sir W. Jardine.

† See Dr Davy's paper in last number of this Journal, p. 347. When the present paper was drawn up, and read before the Linnean Society, I was not aware that Dr Davy had communicated his notice to this Journal. Otherwise I should have been glad to have quoted more freely from his interesting notes upon this subject.—W. B.

Coregonus Willughbii, or Lochmaben vendace, is identical with the *Coregonus* (*salmo*) *albula*, Linnæus, of the Fauna Suecica; and that it occurs in Dalecarlia and Lake Miæs, in Silesia, Brandenburg, Pomerania, and Mecklenbourg, and that an extremely similar, if not identical, species has been found even in Kamtschatka. Far from being restricted, therefore, in its habitat, the vendace would appear, on the contrary, to have a wide geographical distribution; and, under whatever name it may ultimately be described, it is now found in the lake district of England and in Wales, and (on the authority of Yarrell) the *C. marænula*, Jenyns, must now rank only as synonymous with the *Coregonus albula*, Linnæus.* I am indebted to Sir W. Jardine for an opportunity of examining the stomachs of the two fishes mentioned above, as taken in Bala Lake and Derwentwater, but the result has shown a considerable difference in the nature of the food from those of Lochmaben, arising probably from the season of the year in which they were caught, viz., winter. The stomach of the Derwentwater fish was completely empty, while that of the Bala Lake specimen contained the debris of numerous aquatic insects, such as the larvæ of tipulæ, the larvæ of small water-beetles, most probably a species of *Hydroporus*, and the remains of some specimens of the perfect insect itself.

The same friend has also kindly supplied me with the stomachs of two specimens of the common trout from Galloway. Though the fact has long been known that great part of the food of these fish consists of entomostraca, I believe none of the species found in their stomachs have ever been properly ascertained. One of these trout was caught in a small loch in Galloway, and the water at the time was observed to be peculiarly prolific in small insects, &c. Upon examining the stomach, I found that it contained a mass of entomostraca in all states of decomposition. Many specimens, however, were quite perfect, and I was delighted to find that the species upon which this trout had been feasting was one hitherto unknown to naturalists. The specimens, as far as I could judge, were all of the same species. This little entomostracan belongs to the family *Daphniidæ*, and forms a species of the genus *Daphnia*, or water-flea. I propose the name for it of *Daphnia Jardinii*. Its distinguishing characters, and which separate it from all other species known to me, are, 1*st*, The shape of the head, which in some respects resembles that of *Daphnia mucronata*, Müller; and, 2*d*, The lengthened form of the body and terminal spine of the carapace, which corresponds pretty nearly with the *D. longispina* of the same author. These two characters, united in the same species, separate it from all others belonging to the genus.

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* See also, upon this subject, Sir W. Jardine's note to Dr Davy's paper, in last number of this Journal, p. 350.

The other trout was taken at Barn Hourie, and its stomach contained a mass of entomostraca of a totally different species. Unfortunately, however, the process of digestion had advanced farther in this trout than in the other, and I was unable to determine the species to which it could be referred. The specimens were numerous, and appeared to be confined to one species alone. It belongs to the family *Cyprididæ*, or those entomostraca in which the body of the animal is contained within a carapace of two valves, exactly resembling a small bivalve shell. The carapace, however, from which the specific characters are chiefly taken, was so completely digested that no trace of it was left, the only parts remaining being the harder portions of the body of the animal, as its maxillæ, natatory organs, or antennæ, and its feet. From these I was able merely to ascertain that the species belonged to the genus *Cypris;* but I hope some future time to have an opportunity of examining a trout from the same water before its dinner has been so far digested.

Description of Species of Entomostraca.

1. *Bosmina Coregoni.*—Carapax sphæricus, valvulæ, in parte inferiore, rotundatæ; antennæ superiores perlongæ, longitudinis corporis toti. *Long.* ⅛ linea. *Hab.* in ventriculo Coregoni Willughbii, in lacu "Lochmaben."

2. *Daphnia Jardinii.*—Caput triangulare, vertice mucronato; valvulæ carapacis, in dorso, rotundatæ, pars inferior mucrone longo terminata; pars anterior arcuata. *Long.* ⅓ linea. *Hab.* in ventriculo Salmonis farionis in comitatu Kircudbright.

On the Influence of Magnetism on Chemical Action—(continued.) By H. F. BAXTER, Esq.

Having already treated of the influence of *magnetism* in its *static* or quiescent condition on *chemical action*,* we shall now speak of its influence in its *dynamic* condition, or when in *motion*, and this will form the second part of our inquiry.

PART II.—*The Influence of Magnetism in its dynamic condition, or when in motion, on Chemical Action.*

We need scarcely remark, that the subject of our present paper necessarily involves the following question, *Can magneto-electric induction occur in fluids (in electrolytes?)* and we shall of necessity have to refer to experiments bearing upon this point.

In speaking of the results obtained by Fresnel and others, Ampère, according to Becquerel, "à avancé que les effets chimiques que l'on à attribués, dans quelques cas, à l'action des aimants, pourraient bien provenir des courants que ces mêmes aimants développent par influence. Il à fait l'application de son principe à la décomposition de l'eau que Fresnel avait cru un instant avoir produite avec des aimants. Il dit que les courants par induction étant instantanés, ne peuvent produire de décompositions; mais les variations d'intensité du magnétisme des barreaux, qui ont lieu en raison des changements continuels de température, peuvent produire un effet semblable à celui que l'on obtient quand l'on approche et que l'on éloigne successivement un aimant des fils de métal. Voilà comment il explique la continuité du courant et celle de l'action chimique qu'il produit."†

Faraday, in several of his researches on magneto-electric induction, has endeavoured to ascertain whether a *current* might not be induced in other liquid conductors besides mercury. "The relation," he says, "of the induced current to the electro-conducting power of the substance, amongst the metals (3152), leads to the presumption, that with other bodies, as water, wax, glass, &c., it is absent only in consequence of the great deficiency of conducting power. . . . . I thought that processes analogous to those employed with the metals might, in such non-conductors as shell-lac, sulphur, &c., yield some results of static electricity (181, 191); and have made many experiments with this view in the intense magnetic field, but without any distinct result."*

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* Edinburgh New Philosophical Journal, New Series, vol. v. p. 235.

† Becquerel "Traité de l'Electricité," t. i. p. 384.

It is not without great diffidence that we enter upon the present investigation, or even suppose that any attempt on our part could lead to a successful result in elucidating this question. The strong conviction, however, which appears to exist, that the absence of the current is due solely to the want of conducting power in the solutions, led us to hope, that by perseverance we might ultimately obtain some evidence of its existence: how far our attempts have been successful remains to be seen.

We shall not enter into any detail of the general facts of magneto-electric induction, as made known by Arago, Faraday, Ampère, Nobili, and a host of other philosophers, as these are to be found in the treatises of Becquerel† and of De la

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* "Experimental Researches," series xxviii., *para.* 3171. Since this paper was drawn up, we find that we have committed a great oversight in not having become acquainted until now with a letter by Faraday to Professor De la Rive, "On Electro-dynamic Induction in Liquids" and inserted in the Phil. Mag. for April 1854. We are glad in having the opportunity of referring to this paper, and only wish we had been aware of it before. Professor Faraday's experiments were different from those we have related; and we cannot do better than to refer to the letter itself. He concludes by stating, "I consider the excitement of induction-currents in liquids not metallic as proved; and, as far as I can judge, they are proportionate in strength to the conducting power of the body in which they are generated. Whether the conduction, by virtue of which they occur, is electrolytic in character or conduction proper, I cannot say. The present phenomena do not aid to settle that question; because the induced current may exist by either the one or the other process. I believe conduction proper exists; and that a very weak induction-current may pass altogether by it, exerting for the time only a tendency to electrolysis, whilst a stronger current may pass partly by it, and partly by full electrolytic action."

† Traité de l'Electricité et du Magnétisme.

Rive;[*] but it may not perhaps be considered unnecessary to state the general principle, as deduced by Faraday,[†] from his investigations:—"If a continuous circuit of conducting matter be traced out, or conceived of, either in a solid or fluid mass of metal, or conducting matter, or in wires or bars of metal, arranged in non-conducting matter or space; which, being moved, crosses lines of magnetic force, or, being still, is, by the translation of a magnet, crossed by such lines of force; and further, if, by inequality of angular motion, or by contrary motion of different parts of the circuit, or by inequality of the motion in the same direction, one part crosses either more or fewer lines than the other, then a current will exist round it due to the differential relation of the two or more intersecting parts during the time of the motion; the direction of which current will be determined (with lines having a given direction of polarity) by the direction of the intersection, combined with the relative amount of the intersection in the two or more efficient and determining (or intersecting) parts of the circuit."

Our first experiments were conducted in the following manner:—The large electro-magnet (Professor Wheatstone's), which we have already described in our former paper, was placed about six feet from the galvanometer, the line of the magnetic poles being in the same line as that of the needles of the galvanometer. A thick glass tube, half an inch in internal diameter, and six inches in length, contained the solution (either a saturated solution of common salt, or an acid solution, consisting of 1 part strong sulphuric acid and 6 of water); into each end a platinum wire, eleven inches in length and $\frac{1}{16}$th of an inch thick, was inserted by means of a cork, about half an inch of the wire being immersed in the solution, and the projecting part bent at right angles; the other extremities of the platinum wire were attached by means of binding-screws to two copper wires, each about six feet in length, and $\frac{1}{10}$th of an inch thick, by which they were connected with the galvanometer. A piece of wood was attached across the wires at the point where the binding-screws were connected, so as to keep the wires firm and steady, and in the centre a string was fastened, which passed through a pulley above; to the under part a brass weight was tied; and by these means the wires could be raised or lowered at pleasure, while standing at the galvanometer. Near the galvanometer the wires were firmly fastened down by means of string, so as to prevent any motion of the whole instrument.

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[*] Treatise on Electricity.

[†] "Experimental Researches," series xxviii., *para.* 3087. We may also refer to the principle, as established by Lenz. *Vide* "Treatise on Electricity," by De la Rive, vol. ii. p. 15.

The *Galvanometer* consisted of but few coils; and upon bringing the electro-magnet into action scarcely any effect was produced upon the instrument.

The *Electro-magnet* was excited by six of Grove's middling-sized cells, and to concentrate the power, one of the soft-iron armatures was employed, leaving a space of about an inch between the poles.

We shall not detail each experiment, but give the general results.

When the circuit was first completed, whichever solution was employed, an effect occurred upon the needle. The circuit was kept closed, and after some time the tube was raised and lowered between the poles before the electro-magnet was excited; a slight tremulous motion of the needle was generally produced. Upon exciting the electro-magnet, and then repeating the experiment, a slight effect appeared to be produced, and continued for some time, but ultimately subsided. Upon passing a loop of single wire between the poles we could always obtain an effect, constant and definite, the direction of the current depending upon the pole; but with the solution, the effect upon the needle gave satisfactory indications, although trifling, for a short time, and the results would then become perplexing, and this with either of the solutions. To whatever cause the effects were due, whether to chemical action on the electrodes, or to the wires intersecting the lines of magnetic force arising from the earth, or those from the magnet, or to the effects of magneto-electric induction which we were seeking, they could, at any rate, traverse the solution.

To avoid the effect, if any, due to the motion of the wires forming the circuit, in our next experiments the electro-magnet was arranged in the following manner. The poles, instead of looking upwards, looked towards the north, the magnet resting on one of its sides, the two poles being in the same perpendicular plane.

Thicker copper wires, ⅛th of an inch thick, were connected with the galvanometer, their free extremities dipping either into two mercurial cups, or being connected with the platinum electrodes by means of binding-screws. A glass tube, ⅜ths of an inch in internal diameter and 10 inches in length, was bent at each extremity at right angles, at one extremity to the extent of an inch, and at the other to the extent of an inch and a half, and in the same direction. Into the former the platinum wire was inserted by means of a cork, and also bent at right angles to the extent of an inch, the other extremity was connected by means of the binding-screw, or mercurial cup, with the copper wire; but this platinum wire was fastened firmly on to a piece of wood, so that the glass tube could rotate upon that portion which formed its axis. A piece of membrane was tied over the other end of the glass tube, to confine the solution, and this dipped into a shallow dish containing the same solution, and which was placed between the poles of the electro-magnet. Into this basin the other platinum electrode, formed of a piece of platinum foil four inches long and two broad, being connected with the other copper wire by means of a copper clamp, dipped. By this arrangement we had the opportunity of passing the tube between the poles of the electro-magnet without moving the wires; but to effect this, whilst standing at the galvanometer, a long piece of wood, which worked upon a pivot, just over the axis of the tube was used, and to this end the tube was fastened, the other extremity, the long end, serving as a handle; this served also as a means of support to the tube during the rotation, and in order to obtain, occasionally, as great amount of rotation as we could, a piece of string was attached to the handle.

Upon the first completion of the circuit, as in the former experiments, an effect occurred upon the needle; and rotating the tube to and fro occasioned a constant current; but this in a great measure subsided, although there was a constant effect. When the tube was placed directly in front of the poles, the magnet being excited, so that three inches should pass between the poles, then, upon rotating the tube, no effect beyond that of mere rotation appeared to occur. When an inch and a half only passed between the poles more decided effects appeared. Generally speaking, the platinum electrode in the dish was *positive.* When the upper pole of the electro-magnet corresponded to the marked pole, and the rotation of the tube was from left to right, a greater effect appeared upon the needle than when the rotation was from right to left; or when the poles were reversed, similar effects appeared upon reversing the rotation. It was very seldom however that we could obtain such definite results as we could wish. If the *current* consequent upon the arrangement of the circuit were powerful, no definite result could be obtained; it was only when the circuit *current* was trifling that the effects appeared.

The tube was arranged so as to pass between the sides of the poles, but this made no difference. There was one circumstance, however, which appeared worthy of notice, viz., that the effects did not appear so striking when nearly the whole of the tube was between the poles as when a small portion—two inches—alone was introduced.

Instead of making the extremity of the tube dip into the solution, mercury was employed as the conductor, in the following manner:—the membrane was removed, and a cork, with a piece of platinum wire, two inches long, inserted into it, closed the tube, about an inch of the wire protruding. Some mercury was placed in a shallow plate, about six inches in diameter, and the platinum foil served as the electrode, as before. With this arrangement the results obtained were similar to those in the last experiments; there was no decided increase in the effect upon the galvanometer as we expected. When the upper pole was the marked pole, the electrode in contact with the mercury was *positive,* upon rotating the tube from left to right, or from east to west. We could not obtain those reversed effects as we could have wished; they occurred occasionally, but were not permanent.

The effects were only obtained with the solutions, and were not observed when distilled water alone was used.

As the results are so masked by the effects that might arise from electro-chemical actions, and a constant effect being continually produced upon the needle during the motion of the tube, we were as much perplexed in these experiments by the results that might arise during the motion of the fluid portion of the circuit in the present instance as we were before, from the effects that might arise from the motion of the wires. We were now led to the experiments in which the *magnet* was the moving part.

The soft-iron bar and helix employed has been already described in our former paper. The bar was suspended vertically to the axis of a wheel moving horizontally, and which was fixed on the upper part of a stand, the centre of the board being cut out. The stand was four feet high, and supported upon four legs. By means of a vertical wheel with a handle, which was attached to the side of the stand by a cross-beam, and by pulleys fixed on the upper part of the stand,—a string surrounding the two wheels,—motion could be given to the upper wheel. The helix was suspended, and firmly fixed by cords, having the iron bar within. The lower end of the bar was placed in a small glass jar, heavy, and a little larger in diameter than that of the bar, so as to avoid any motion of the fluid during its rotation, and likewise any chemical action from occurring upon it.

A shallow basin, six inches in diameter and an inch and a half in depth, contained the solution. A piece of platinum foil three inches and a quarter in length, and an inch and a quarter in breadth, was placed upon the bottom of the basin, the small glass jar containing the pole of the electro-magnet being upon it; this formed the lower electrode. The upper electrode consisted of a similar piece of platinum foil, or sometimes two narrow strips, so as to pass on each side of the jar horizontally or vertically. The electrodes communicated with two wooden cups containing mercury, the lower one by means of a platinum wire, bent so as to dip into the fluid and press upon the platinum foil, being coated with sealing-wax for two inches, leaving about a quarter of an inch bare at the extremity, so as to prevent any current being conducted from the other electrode, which communicated with the mercury by means of a copper clamp.

The *Galvanometer* was placed about 3 feet from the pole of the magnet, and on a level with it. The communication between it and the mercurial cups was formed by pieces of copper wire ⅛th of an inch thick and 3 feet in length. At this distance, when the electro-magnet was excited, no sensible effect was produced upon the needle, and when the bar was made to rotate, a slight tremulous motion sometimes occurred.

We need scarcely add, that great care was required to have the contacts perfect, and the platinum electrodes thoroughly cleansed.

The electrodes being rather more than an inch apart, the basin was filled with the *acid* solution, so as just to cover the surface of the upper electrode. The circuit being completed, an effect occurred upon the needle, varying as to amount; this soon subsided; but it generally happened that one of the electrodes continued positive throughout the experiment. Upon rotating the bar, the magnet being excited, a slight motion was observed upon the needle, and, by catching the vibrations of the needle at proper times an effect of 3° or 4° could be ultimately obtained; and by reversing the rotation of the bar, an effect upon the needle was obtained in the opposite direction, amounting perhaps to as many degrees. When the lower pole was north, or corresponding to the marked end of the needle, and the bar rotated like the hands of a watch, the face looking downwards, the lower electrode was *positive, i.e.*, coincided with the platinum plate of a simple voltaic circle. When it rotated in the *opposite* direction the upper electrode was then *positive.**

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* Mr Hunt records an experiment (*Phil. Mag.*, April 1848), in which he placed a helix, surrounding an iron wire, in an electrolyte, and upon completing the circuit of the helix to magnetize the wire, an effect occurred upon the needle. "In every instance," he says, "upon either making or breaking con-

There was something peculiar in the motion of the needle, for it was very steady or slow in its movement, acting as if time was required, and it was difficult to know when to catch the vibrations. There was not that sharp, quick motion usually observed when studying electro-chemical effects; and it was only when a quick and sharp rotatory movement was impressed upon the bar that it became quickened.

One or two other circumstances were observed which appear deserving of notice. Upon rotating the bar in one direction, it sometimes happened that no effect was produced, but upon rotating it in the contrary direction, the current was easily procured, and in the normal direction. Again, upon rotating the bar in either direction the normal effect was produced, viz., 3° or 4° in both directions; but occasionally the needle would suddenly move 10° or 15°, or more, as if a sudden impulse had been given to it; and whenever the rotation coincided with that direction, this increased amount would continue. Now, these effects, we are inclined to believe, are due, the first to the current which existed in the circuit, and which may be called the *circuit-current*, being too powerful to allow the normal current to travel in the opposite direction; and the second, to the circumstance that a sudden chemical effect was produced coinciding with the normal current. Upon breaking the circuit, and uniting the wires afterwards, indications of a *reversed* current were obtained; but these have been frequently observed under other circumstances, when there was no rea-

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nection, the needle of the galvanometer vibrated from 3° to 5°, but steadily returned to its permanent deflection. . . . . The transient disturbance of the needle arose from the passage of an induced current through the electrolyte, and by the wires to the galvanometer." But the case he considers as "precisely similar to one recorded by Faraday," which he quotes. This is a voltaic circle in an *induced* circuit. We could never understand how the effects could be referred to those as recorded by Faraday, provided the wires were well insulated. The action upon the needle in Mr Hunt's experiment was not *constant*, but *temporary*; and if the motion of the needle could not be referred to the direct influence of the magnetism of the helix or wire, we are more inclined to consider it as an effect of *magneto-electric induction*, a temporary current being formed either in the metallic conductor or solution, and able to *traverse* the electrolyte.

son to suppose that chemical action had occurred, unless we must consider this fact as evidence of its having taken place. We are now led to inquire whether a solution (an electrolyte) can conduct a current without undergoing decomposition? But before discussing this question, we must refer to a circumstance which was at first rather perplexing, as well as to some other experiments.

Upon repeating these experiments on other occasions, it occasionally happened that no effect could be obtained, or the results were doubtful, the current passing at one time in one direction, and then in the opposite direction. The reason of this we shall be able to point out afterwards.

When a *saturated solution of common salt* was employed, instead of the *acid solution*, effects similar to those already described were obtained. With *water* alone no effect was obtained.

Instead of *platinum* two *amalgamated zinc* plates were used as the electrodes, each about five inches and a half in length, and two inches broad; in the upper one a notch was made, so as to admit of the glass jar containing the pole. With these plates, using *water* as the liquid, the chemical action was too powerful to obtain any decisive result. The slightest motion of the fluid in the basin caused an action upon the needle, and the effects sought for were completely masked by those resulting from chemical action.

With *copper* plates of the same size as the zinc, and using copper wires instead of the platinum wires, with a *concentrated solution of sulphate of copper* as the interposed liquid, more satisfactory results were obtained. The amount of effect upon the needle was not greater than 3° or 4°. If the circuit current was in one direction, the induced current was readily obtained in that direction. With the *acid* solution the chemical effect was too powerful, the effects being similar to those obtained with the zinc plates. With *water* alone no effect was obtained.

Returning to those experiments in which the *platinum* electrodes were used, and which appeared to give the most decisive results, and reflecting upon the *direction* the *current* took, viz., the lower electrode being *positive;* it seemed possible, after all, that the current might not be *induced* in the *liquid,* but that it merely traversed it. The following experiment was now performed :—

A large glass tube, two inches in diameter, and six inches in length, had a piece of membrane tied over the lower end, and was then filled with the *acid* solution, and placed upon the lower platinum electrode as before, the basin containing some of the same solution. The upper electrode was placed sometimes horizontally, at other times vertically, at the upper portion of the fluid in the tube. The lower pole of the electro-magnet was now outside of the tube, but close to it, and extended about two inches down from the top. Upon rotating the bar, an effect was obtained upon the needle, and by catching the vibrations of the needle at proper times, by rotating in the reverse direction, it was made to increase; the effects being similar to those we had already obtained. But the current was now *reversed,* or the *upper* electrode was now *positive.* So here we had the current *induced* in the fluid, unless we suppose it to have been due entirely to the platinum electrode, or to the metallic part of the circuit.* The bar was rotated within the deep jar as before, in the centre of the fluid, but the effects did not appear to be increased. The experiment was repeated with shorter tubes with similar results, but with this exception,—when the lower electrode was brought up to within an inch of the pole, the effects upon the needle began to vary, and the nearer it was brought to the pole it then became *positive* as in former experiments.

When we consider the arrangement of the *lines of force* of a magnet, it is reasonable to suppose that the situation and position of the two electrodes, in reference to the course of these lines, must be of some, if not of great importance; one being *positive* or *negative* to the other, according to circumstances. That such is the case, we may infer from the principle established by Faraday, and which we have quoted at the commencement of the present paper. In these latter experiments, the lower electrode was placed out of *the lines of force,* or at any rate in such a position relative to the lines that it was ineffectual in originating the current, or acting as the *cathode,* thus becoming *negative* to the other, and we now obtain a clue to the circumstance that was formerly perplexing to us, viz., the current traversing the galvanometer sometimes in one direction, at other times in another. There can be no doubt that the bar in those instances might have been raised, and again, as the magnetic power of the bar began to sink so would *the lines of force* fall in upon the magnet. So here we have three important circumstances to attend to, and to take into consideration in these experiments, *First,* The *position* of the electrodes, whether *axial, radial,* or *equatorial,* in reference to *the lines of force; Secondly,* Their *distance* from each other, whether *both* or only *one* of the electrodes are within *the lines of force* or *sphondyloid;* and *Thirdly,* The *strength* of the magnet, or magnetic *sphondyloid.*

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* We can scarcely suppose that the current was induced in the glass rather than in the solution or fluid conductor, yet Mr Harris found that the rotation observed in Arago's experiment could be obtained with annealed glass, but not with sulphuric acid and saturated solution of sulphate of iron. *Vide* Faraday's "Experimental Researches," series i., *par.* 130.

We may add, that when using the platinum wires alone as electrodes, instead of the foil, effects, though perhaps not to the same amount, were obtained upon the needle; but we have never been able to keep the needle deflected to a certain distance by rotating the magnet in one constant direction; it always appeared to be in a continual state of vibration. This may, however, arise from the bar, as from its mode of suspension, it did not revolve freely within the helix, and occasionally stopped in consequence of the friction against the sides.

We tried several times to obtain signs of *polar decomposition,* and for this purpose we placed some *concentrated solution of iodide of potassium and starch* in a tube, using the platinum electrodes, either wires or foil, and rotating the bar in one constant direction, but have not as yet been able to obtain as definite evidence as could have been wished, although the galvanometer, in these experiments, was affected. The change of colour that did appear was too general, and not confined to the *anode.*

The experiments were repeated with the *osmometer*, viz., by rotating the electro-magnet in one constant direction, the septum being either *horizontal* or *perpendicular* to the *lines of magnetic force;* but in these instances no definite result was obtained.

We endeavoured to ascertain whether the *rotatory* motion, which occurs when a solution acts chemically upon a metallic cylinder inclosing a pole of the magnet, is affected upon rotating the pole. When zinc or copper cylinders were used some effect appeared; but it was too slight, and the results might have been due to the unsteady motion of the bar, or to other causes than to the mere rotation of the pole. When a cylinder of soft iron, however, was employed, no effect occurred.

Concluding Remarks.

In bringing this imperfect inquiry to a close, we shall add one or two observations upon the question originally proposed, viz., "The influence of *Magnetism* in its *dynamic* condition, or when in *motion*, on *chemical action.*"

The only positive conclusion that we can deduce from the foregoing experiments is the following:—*That the currents consequent upon magneto-electric induction may be excited in fluid conductors, such as electrolytes.* The question, however, whether an electrolyte can conduct an electric current, without undergoing decomposition? may be considered a disputed point, but the evidence that has been adduced in favour of the supposition that it can do so appears to us to preponderate, and we can only refer to a valuable lecture* by Professor Faraday, "On Electric Conduction," in which he considers that a liquid (an electrolyte) may possess "*conduction proper*" as well as "*electrolytic conduction,*" and that the former does not necessarily imply the latter. Although an electrolyte may possess "*conduction proper,*" it is reasonable to suppose, that if the forces by which the elements of the electrolyte are held together be feeble, then, according to the *intensity* of the current, so would decomposition occur. Some results observed in the foregoing experiments would lead to the conclusion that this might have been the case, for, when using the acid solution and the platinum electrodes, and rotating the bar in one constant direction, the needle was sometimes suddenly deflected several degrees. In this case, the current, although weak, might have induced a tendency to, which ultimately resulted in, chemical action. In other instances, whenever conditions exist so as to render the chemical forces so equally balanced that a slight circumstance might be capable of overthrowing this equilibrium, we might then expect that the weakest current would be able to effect this. Our failures in obtaining *polar decomposition* were evidently due to the want of *intensity* in the current, and as we have every reason to believe that this may be increased by more powerful means, so may more decided chemical effects be produced. Hence we may arrive at the conclusion, *that magnetism (in its dynamic condition, or when in motion), may excite or originate, and increase chemical action.*

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* Journal of Royal Institution. May 25, 1855.

On the Occultation of Rivers. By THOMAS S. TRAILL, M.D., Professor of Medical Jurisprudence in the University of Edinburgh.

The disappearance of some rivers into chasms in the earth, and their reappearance at the surface, has attracted attention from very ancient times; and several instances of this curious phenomenon are alluded to by both Greek and Roman authors. This has chiefly been observed among strata of limestone or of gypsum; and has been more frequently noticed in the Peloponnesus than in any other part of the world. The fervid imaginations of the ancient Greeks generally clothed such occultations with mythological fiction, and adorned them with the graces of poetic imagery. That temperament, which led them to people every grove, and animate every stream with presiding deities, could easily imagine subterranean rivers traversing extensive regions, and with little difficulty reconcile itself to the fabled loves of Alpheius and Arethusa; which led the enamoured river god to pursue his coy nymph from the mountains of Peloponnesus, even in ocean's bed, to the shores of Sicily.

The best account ever given of the occultations of Grecian rivers is contained in the valuable travels of Colonel Martin Leake, in *The Morea;* a work in which he has admirably illustrated the descriptions of Pausanias, the notices of Strabo and of the Greek historians.

He justly remarks, that the disappearance of the Peloponnesian streams is better known than their emissories. The former, in the language of Greece, are termed *βερεθρα*, or in the Arcadian dialect *ζερεθρα*, and often, in the common language of the present inhabitants *καταβοθρα* (pronounced *katavóthra*).

Either from tradition, received from their forefathers, or from observation, the modern Greeks are no less persuaded of the reappearance of the engulfed streams than were their celebrated ancestors. But it is to be regretted, that in modern times no experiments have been made on this curious subject, to corroborate this opinion, especially in a country so abounding in instances of *occultation;* and one of the objects of this paper is to point out a simple method of determining the true emissories of such subterranean streams, after I have given a brief account of the best known *ζερεθρα* of Peloponnesus, which are chiefly in Arcadia, its central province, and of a few in Western Europe.

The valleys of Arcadia, which have no other exit for their running waters but *zerethra*, are those of Tegea, Mantineia, Asea, Orchomenos, Alea, Stymphalus, and Phineus. Of their zerethra the following is believed to be the distribution :—

1. In the Tegeatice there are two zerethra; one at Taki, which discharges its engulfed waters into the valley Asea; the other disappears at Persová, and has its emissory, it is said, in the sea, on the coast of Argolis, at the place called Δεῖνη (*Deine*) by the ancients.

2. In the Mantinice there is one, which disappears near the ruins of Mantineia, and is stated to have its emissory in the valley of the Helisson, near Daviá.

3. In the Asæa there is one, perhaps two zerethra; the emissory of the first is in the pegæ of Megalopolis; and the other is believed to be one of the sources of the Eurotas, near Belemina.

4. The river of Orchomenos is engulfed in the zerethra of Caphyæ, and reappears at Rheunus, near the modern Tara, whence it falls into the river Ladon.

5. That in the Alæa is near the modern town of Skotiní, and is considered as having its emissory in the fountain of Teneiæ, near Orchomenos.

6. The river which enters the zerethra of Stamphylus is said to reappear near Argos; but Colonel Leake thinks that this emissory is that of a river which is engulfed in the Valley of Késari.

7. In the Pheneatice there are two zerethra; one of which engulfs the river Aroanius, which reappears in the sources of the Ladon, below Lycuria. Leake was unable to ascertain the emissory of the other. The same traveller believes that there are several smaller zerethra, of which no account has yet been given by any writer.

The most noted of all these is the alleged commingling of the waters of the Alpheius and Eurotas. Pausanias describes the two rivers as arising not far from each other, then mingling their waters for a distance of about 20 stadia, when they pour into a chasm in a mountain, within the bowels of which the waters separate, to form two distinct rivers; one of which, reappearing in the Laconice, forms the Eurotas; the other, the Alpheius, reappearing in the pegæ of the Megalopolis. The story recorded by Strabo, to show their subterranean separation, is evidently fabulous, viz., that if a garland were consecrated to each river, and both simultaneously thrown into their zerethra, each would make its appearance in the river to which it was dedicated.

In western Europe, the most celebrated instance of the occultation of a river *was* that of the Rhone, near Bellegarde, on the confines of France and Savoy, about 18 miles from Geneva; but, alas, on visiting this interesting spot in the autumn of 1855, I found that the *Perte du Rhone* no longer exists; for the Sardinian Government, in which territory it was, had blown up the rocky roof, beneath which it had been engulfed, in order to facilitate the conveyance of timber on the river. At that point the Rhone had contracted to a narrow but deep stream, and disappeared below the rocky strata, for a distance of 180 feet in length. The deep chasm is now open to the day, and the traveller crosses the river on an artificial bridge, instead of the grand one of nature's masonry.

In Spain, there is another remarkable occultation, that of the considerable river, the Guadiana, in New Castile. It disappears in a chasm near the village of Castillo de Cervera; and, after a subterranean course of about 15 or 16 English miles, it issues into day, near the high road from the Sierra Morena to Madrid, at a place named *Los ochos de Guadiana* (the eyes of the Guadiana), between Manzanares and Villaharta. At the Venta de Quesad, about three leagues north of Manzanares, I found a well, which happened to be dug on the concealed river that flows here at the depth of 38 varas, or 114 feet.

In Britain we have a few minor instances of river occultation, particularly in the limestone of the counties of Derby and York.

The small streams named the Manifold and the Hamps sink into a chasm on a common near Ashburn, and reappear about three miles below, in Ilam grounds. The stream which issues from the cavern of the *Peak* is that which disappears near the high road from Chapel-le-Frith to Castleton, about three miles from the latter town. Similar instances occur in the streams in Weatheroote and Yordas caves, on the western borders of Yorkshire.

With regard to the method of investigating the course of subterranean streams, it occurred to me, when gazing on the grand emissory of the Guadiana, that the usual modes were not satisfactory. It is generally recommended, to throw into the zerethra light floating bodies, such as leaves, chips of wood, or chaff, and noticing their reappearance. When the subterranean course is long and tortuous, the time of waiting for their reappearance will not suit the traveller; especially as such bodies, from their extreme lightness, and angular form, will be very apt to be detained by projections of the channel; or where the water entirely fills it, to be left behind: besides which, such common objects are not easily identified as the individual articles committed to the waters of the zerethra.

It seems to me, that it would be preferable to employ a number of turned balls of wood, from ½ to ¾ of an inch in diameter, which, for identification, might be stamped by a hot iron with a particular mark or letter. Such should not be very much lighter than water, that they might be less likely to be stopped by inequalities in the roof of the subterranean channel, or its sinuosities. Turned spheres of beech or of ash, which have a specific gravity of 0·845 and 0·840 respectively, would be preferable to balls of fir or cork, with a specific gravity of 0·540 and 0·240; while the softness of the two last would render them more liable to chafing by friction in their passage, and therefore to detention.

A handful or two of such spheres, thrown into any chasm engulfing a stream, would seem a more certain mode of ascertaining the emissory than employing substances so easily to be mistaken as leaves, chips, or chaff.

Chronological Remarks on the River Wye. By CHARLES RICHARDSON, Ross, Herefordshire.

All along the river, as well as in the small district near Ross to which our attention is now more particularly confined, the Wye runs through level alluvial land, varying in width from 100 yards or less, in localities where the rock is hard and the hills high, to a mile and a half in places where the material is softer and the country more level; and this alluvial land is bounded by cliffs which follow the "general course"* of the river.

Let us consider, in the first place, what evidences we have to prove that this alluvial land and these cliffs have, in the course of time, been formed by the river itself.

With regard to the alluvial land, it is to be noticed that the river runs across it from cliff to cliff, in bends of a peculiar form, and of an average length, in this district, of about a mile; there being six such bends in the six miles of the small district alluded to. At each of these bends, the water constantly wears away the bank on the *convex* side, while the opposite bank is made up at an equal rate by deposition of the sediment, so that the river always preserves its average width; and this wearing away of the one bank, and forming on the other side, is sufficiently rapid to be notoriously observable by all living in the vicinity, many persons recollecting *acres* gained on one side, in a single field, and lost on the opposite side, during their lifetimes.

The cause of the wearing away on the convex side of the bend, and of the deposition on the concave side, is sufficiently obvious; it occurs during "freshes," when the river is "bank full," (the water is usually about ten feet below the surface of the alluvial land), and the water runs at the rate of about five miles an hour, and is loaded with sediment.

If the stream, at such a time, be attentively observed where there is a bend in its course, it will be at once seen that the current sets against the convex bank,* which it consequently wears away; but that on the other side, the speed of the current gradually diminishes in proportion to the distance from the main stream. Now, where the stream is at its full force, its tendency is to detach and carry away fresh particles, which it does from the convex bank; but as the speed becomes slower, towards the concave side, the coarser and heavier particles are first deposited, while the finer are carried farther in-shore, into quieter water, and there deposited, and so on; the fineness of the particles deposited bearing an exact proportion to the speed of the current at each successive point; and, as the great bulk of the particles are nearly of equal weight, it follows that the greatest amount of deposition will occur in a certain *zone*, somewhere intermediate between the first commencement of deposition and comparative rest.

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* When the term "general course" of the river is used, the direction of the alluvial land between the cliffs is meant.

We see evidences of this all along the river; for, as in some seasons the banks are worn away much more than in others, or from some such cause, a wide margin for deposition is suddenly opened, then the chief amount of deposition takes place at a certain distance from the main current, while further in-shore the deposition is less, so that the land rises in the form of a bank or ridge near the water's edge, leaving a strip of much lower land further in-shore, which is only very slowly, in comparison, raised by deposition. These ridges, which show a former course of the river, may be traced here and there in all parts of the more recent alluvial land. A conspicuous example of this occurs where the "Ross oak" stands, as will be noticed presently.

If the way in which the land is formed by the river be observed at any favourable spot, of which we have good examples at the Backney, Ross, and Wearend bends, it will be seen that first a bank of coarse gravel is formed on the rock bottom of the river, and on that is deposited a fine gravel or coarse sand, and then mud and substances not much differing in specific gravity from water, such as water-logged timber, &c., and shells of some fresh-water molluscs indigenous to the river; and lastly, on this, a thickness of from six to nine feet of earth, hardly distinguishable in appearance from the mould of this country.

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* At the bends in the river, the terms *convex* and *concave* are applied with reference to the stream itself; thus the bank on the convex side of the *stream* is called the convex bank, though its form, as regards itself individually, is concave; the expression, which should be "the bank on the convex side of the river," is used for the sake of brevity.

Now, if the formation or structure of the alluvial land be examined at any point,—either away from the present course of the river, by digging (as I have had the opportunity in many places where trial pits have been dug, and where the foundations of the railway bridges and viaducts were put in), or at those places where the bank is being washed away by the river,—the same evidences of river deposition will invariably be found. At one place near the Wearend, where the bank has been rapidly washed away, trunks of large trees have been gradually exposed, and even layers of leaves and hazel nuts have been found, all, of course, quite black and much decomposed.

Then, as respects the formation of the cliffs. If all the surrounding country be examined, the surface will be found to be of a gently undulating and rounded character, and without any instance of an abrupt cliff occurring anywhere excepting only those by the river; while, on the other hand, these cliffs are to be found of a greater or less elevation on both sides, and along the entire course of the river, intersecting in all ways the regular contour of the hills, but always following the general course of the stream. Now, if, in a district such as this, where all the hills are of a gently rounded outline, we saw one hill abruptly cut away on one side, so as to form a cliff, we should naturally look around for a cause for so singular an effect; but when we see that cliff conformable to the course of the river, and not only that one hill, but every hill all along the course of the stream similarly cut away, and always with equal conformity to the river's course; and when, in addition to this, it is seen that where the general course of the river makes a bend the hills on the convex side are much worn away, while those on the concave side are much less worn, the conclusion is irresistible that the cliffs and alluvial land must be due to the action of the river.

That these cliffs did not exist immediately after the diluvial period, or, in other words, were not coeval with the adjoining surface of the hill, we have clear proof in the fact, that the "surface-softening," presently to be alluded to, has not sensibly affected the beds of rock exposed at the bottom of the cliffs.

We may presume that the river first commenced running down its course immediately after the land had been lifted to its present elevation, when the waters of course sought the lowest channel.

We have in this country strong evidences of great diluvial action or "denudation" immediately preceding this period, during which the undulating and rounded character was given to the surface. A striking instance of this may be seen on the higher hills, skirting the Forest of Dean, where a very thick and strong bed of old red conglomerate occurs, underlying the lowest beds of the mountain limestone formation 320 feet, as ascertained by measurement in the Little Doward Hill. This "great sandstone bed," usually about 20 feet in thickness, is seen cropping out on the north-western slopes of the undermentioned hills:—Penyard, Warm Hill, Lea Bailey, Bishops' Wood, Copped Wood, Huntsham, Great and Little Doward, and at Staunton, where it forms the ridge or summit of the Buckstone Hill (one of the highest in the Forest of Dean), the old Buckstone, or rocking-stone, itself being a piece of it.

Now, wherever this "great bed" occurs, the rounded contour of the hill is broken, and we have a twenty feet cliff, as might be expected, from diluvial action, and great masses, many as large as a cottage, that have fallen from this bed during the process of denudation, lie scattered below; a very remarkable circumstance (as may be well observed in Copped Wood Common) being, that many of these great blocks have stopped, hanging in singular and fantastic attitudes, half-way down the steep hill-side, where it is not very easy for a man to stand; others have reached the bottom, but none have rolled many yards on the level, affording clear and unmistakeable proof of submersion at the time of their fall; for, if such masses of rock had not been checked in their descent by water, it is evident that they must have rolled, not only to the bottom of the hill, but a long way on the level beyond.

One other peculiarity may also be noticed in this district, that no firm and hard sandstone rock is to be met with until at a depth of 15 or 20 feet below the surface, excepting *only* the "great bed" just alluded to. Abundant opportunities of observing this occur all over the country, and, recently, more particularly in the railway cuttings; the beds can be followed from a depth of 40 or 50 feet to the surface, where they crop out. From some of these beds was obtained as good building stone as any used in this country, but always from a depth of more than 20 feet below the soil; and if these same beds be followed towards their out-crop, they gradually become softer as they approach the surface, until, when within 10 feet of it, they are found to be what is, in the langauge of this country, expressively called "Dunstone," a kind of indurated sand, in the *form* of rock, neither sand nor stone, and which may be broken between the fingers.

Now, as this surface-softening invariably affects *all* beds in *every hill* in this district (save the one already mentioned), and as the "dunstone" is to be found only near the surface, it must be attributed to atmospheric action, subsequent to denudation continued through a vast period of time. That no surface-softening took place *during* the diluvial period, we may infer from the fact that such beds as are still under water remain hard and firm, although near the surface. This may readily be observed in any part of the river at low water, when the hard rock bottom is seldom more than 3 or 4 feet under water. A noticeable fact, also, is, that the hardest and best beds in a quarry are usually found just beneath a bed of marl, which would naturally be less pervious to atmospheric influences.

It may here be remarked, that the "great bed" is the only one that has really resisted the atmospheric action, and is consequently (speaking of this district) the only bed of sandstone truly adapted to the building of important national structures, such as cathedrals, &c. The truth of this remark may be ascertained by an inspection of Hereford Cathedral, or any old structure built of the ordinary stone of this country.

It has been stated, that the river runs across the alluvial land from cliff to cliff, in bends averaging a mile in length in this district. Now, wherever the river arrives at the cliff, a portion of it, certainly not exceeding 107 yards on an average, is exposed and undergoing "wear" (this length of 107 yards is a very *full* average, and is the result of careful measurement of the most decided cases);* while along the remaining distance, 1653 yards, measured in the direction of the cliff, and not along the river channel, the alluvial land alone is exposed to the action of the current. The *rate* at which the river wears away this alluvial land has now to be considered.

There is still in existence an old survey of the Guy's Hospital estates near Ross,† made by John Green in 1756, just 100 years ago, and by comparing the present position of the river with that shown on this survey, the alteration in its course is at once apparent. There is also a celebrated old oak tree, called the "Ross oak," growing near the Ross bend of the river, which was, at the date of that map, thought worthy of record. The distance of this tree from the present river bank is 170 yards, but on J. Green's survey it is only 118 yards; the river must consequently have made 52 yards of land at that place in the century; and supposing the land to have been made at the same rate, about 327 years ago it must have run close under the bank on which the old oak grows, from whence, as has been before stated, the old river bank can be distinctly traced all the way to the cliff at Wilton Castle. This old oak has been noted for many years; it is 29 feet in circumference at 3 feet from the ground, and when it was set on fire in the winter of 1849–50, notices of it were inserted in the London papers; in many, its age was put down at 900 years, and in some at a much larger figure. Now it happens that we have the means of arriving very nearly at its true age; at the time of the fire the hollow trunk was burnt so thin that the enormous limb which formed the top of the tree, fell, and when sawn through was discovered to be solid at a height of what had been rather more than 30 feet from the ground, and was ascertained, by counting the concentric rings, to be 278 years old. Now, if 40 years be added for the time required for an oak to attain the height of about 30 feet, we shall have 40 + 278 + 7 = 325 years for the age of the tree, which, supposing the oak to have been a sapling on the bank of the river of that day, agrees remarkably with the former estimate of the rate of wear and deposition obtained from the old survey. It may also be added that on examining the shell of the hollow trunk at the time of the fire it was found that it had grown 5¾ inches in the last 50 years; now it must have grown much more rapidly when a younger tree; if we suppose at double the rate just mentioned, that will make an average of half as fast again during the whole term, and, as the entire growth or radius of the trunk is 55 inches, we shall have the age of the tree 316 years; agreeing as nearly as could be expected with the more precise calculation above.

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* The bends in the river channel do not *all* reach the cliffs, and the exceptions are of two kinds; the first those where the wearing of the banks has been (of comparatively late years) impeded by "cribbs," or walling built purposely to stop the encroachment of the river; and the second those in which the river, in its natural course, does not arrive at the margin of the alluvial land; these latter occur chiefly on the *concave* side of a bend in the general course of the river. We have, however, in the subsequent calculation, assumed that the cliffs were always and invariably subjected to their usual "wear" at each epoch.

† For a copy of this survey I am indebted to the kindness of J. S. Taylor, solicitor to the governors of Guy's Hospital.

At the Wearend, the rate at which the alluvial land has been worn away, as obtained from J. Green's survey, appears to have been nearly 60 yards during the century; but as we have the opportunity of estimating the rate of wear for 327 years at the Ross bend, that rate has been assumed as the basis of the subjoined calculation.

Now in 327 years, the Ross bend in the river has progressed downwards (towards the sea) a distance of 170 yards, and, supposing the process to continue at the same rate, it would reach the present site of the bend at the Wearend, just a mile below, in about 3384 years; therefore, as the distance between these bends is exactly the average distance from bend to bend all along this part of the river, we may call that period of 3384 years an "epoch" in the age of the river; and during this "epoch" the bounding cliffs would have undergone their usual process of wear all along the course of the river.

We will now proceed to consider the *length of time* required by the river to wear away the cliffs to their present form.

Sections of the surface of the ground have been made in several places across the general course of the river, showing the manner in which the cliff at that point intersects the rounded contour of the surface, and enabling us to form a tolerable idea of what the surface was before the river had worn it away.

This surface, as it may be supposed to have existed when the river first ran down its course, has been marked on these sections with a dotted line; and by measurement, the amount of land (or cliff) worn away cannot have been *less* than 400 yards.

As regards the *rate* at which these cliffs are worn away, we have a very good example at the Wilton Bridge. That bridge was built in 1599, 257 years ago; the masonry of the western abutment was founded on an exposed ledge of rock which stands high enough to be dry whenever the water is low, and yet low enough to be under water on the occurrence of the least "fresh" down the river; it is, in fact, just about the elevation that would subject it to the alternations of being wet and dry most frequently, or, in other words, to the greatest amount of wear. Now this bed is by no means composed of the best and firmest quality of stone in this district, for it is comparatively thin, and what is here called "shelly," or composed of laminæ of about half an inch in thickness, and it is only 15 or 16 feet below the original surface, but it is certainly a very hard bed considering that circumstance.

The whole surface of this bed has, in the course of the 257 years, been worn away 3¼ inches, and we may fairly assume that the rocks forming the general cliff were certainly not worn away at a more rapid rate, for they contain, everywhere, decidedly better and stronger beds of rock than this at Wilton Bridge.

Now what must have been the process by which the cliffs were formed from the commencement? When the river first ran down its course, it sought the lowest ground, and must there have gradually worn for itself a channel; then would begin its "meandering," as it may be called, between its bounding cliffs, and the formation of the alluvial land. These bounding cliffs would, of course, be but a short distance apart at first, and the *bends* would consequently pass from cliff to cliff in a shorter distance than when the breadth of the alluvial land became greater; in other words, the duration of what has been called the "epoch" would, at first, have been zero, and would gradually have increased as the width of the alluvial land extended, until it became what we now find it. From this it might have been supposed, on first thoughts, that the duration of the epoch has been, on an average, and reckoning from the commencement, *one-half* what it is now; the common arithmetical mean, however, is not correct in this case, as will be at once perceived when it is considered what the length of the epoch would be when the alluvial land was only a few yards in width, say five for example; for the average of one-half to be correct, the river, after wearing the cliff for a distance of 107 yards, must have left it, gone 5 yards away, and returned to it again in a distance of about 20 yards. This is clearly incompatible with the *curvature* of the river channel; and, judging by that curvature as at present existing, the river could not have left the cliff and returned to it again, after going 5 yards from it, in a less distance than 180 yards.

As our object is now to ascertain, as nearly as possible, the true average duration of the epoch from the commencement to the present time, it must be borne in mind, in the first place, that the distance from bend to bend is made up of two quantities, first, the part where the cliff is supposed to be in "wear," namely, the invariable length of 107 yards, a constant quantity; and, secondly, the part of the cliff *not* exposed, a quantity varying with the width of the alluvial land. For the sake of brevity, let us call this second quantity the "length," and the corresponding width of alluvial land the "breadth."

We have one fact that will help us to arrive at a correct average; at a part of the river where the "breadth" is about 50 yards, the "length" is as nearly as possible 1000 yards; and, assuming our estimated "length" to be tolerably correct where the "breadth" is 5 yards, we have these figures—

"Breadth"	5	"Length"	180
"	150	"	1000
"	400	"	1653

From these figures it appears that the "breadth" varies directly as the square of the "length;" and consequently, that if the "lengths" be taken along a horizontal line, and the corresponding "breadths" perpendicular to that line, the points so obtained will be in a parabolic curve; therefore, from a property of this curve, the average "length" will be just two-thirds of what it is now, or 1102 yards.* We have, therefore 107 yards as the length undergoing wear, and 1102 the average "length" exempted, making together 1209, the *average* distance from bend to bend from the commencement, which, at the rate of 52 yards in the century, makes the average "epoch" 2325 years.

Now at the rate of 52 yards in 100 years, the 107 yards of cliff would be subject to wear for a period of 206 years, and would, at the rate obtained from the bed at Wilton Bridge, be worn back three inches during that time, when that portion of cliff would be exempted from wear for the remainder of that epoch, namely, according to the average just obtained, for the rest of the 2325 years.

* That the "breadths" are as the square of the "lengths" appears from these figures $\overline{1653}|^2 : 400 = \overline{1000}|^2 : 150 = \overline{180}|^2 : 5$, very nearly, the true figures being $\overline{1653}|^2 : 400 = \overline{1012}|^2 : 150 = \overline{185}|^2 : 5$.

By this proportion we can ascertain the "lengths" where the "breadths" are 300, 50, and 20 yards, and putting them into a tabular form we have

"Breadth"	400	"Length"	1653
"	300	"	1432
"	150	"	1012
"	50	"	584
"	20	"	370
"	5	"	185

Taking common arithmetical averages between these figures and then reducing such averages, each in proportion to its length, to a *common* average, we have 1091 for the result, which is only 11 less than two-thirds of 1653, the present "length." And if a greater number of co-ordinates had been employed, the result would have approached still more nearly to the two-thirds, which may therefore be taken as the limit or true average."

Therefore, as we find that the cliffs have been worn back 400 yards in all, and 3 inches at each epoch, there must have been 4800 epochs; and, as the average length of the epoch is 2325 years, the river must have first begun to wear its banks 4800 × 2325, or more than 11,000,000 years ago.

This result may be obtained otherwise, thus: At the rate of the bed at Wilton Bridge, rock would wear when *constantly* exposed to the action of the river, $3\frac{3}{4}$ inches in 257 years, or a yard in 2467 years; but as only 107 yards out of 1209 are in wear at any one time, the time it must have taken to wear a yard was $2467 \times \frac{1209}{107} = 27{,}877$ years, and as 400 yards have been so worn away in the whole, it must have taken 400 × 27,877, or about 11,150,000 years.

The circumstances that make the river Wye, in this district peculiarly eligible for this argument are:—

Firstly, it is a large stream, uninfluenced by tides, and having, for so considerable a stream, a great fall, as much as $2\frac{1}{2}$ feet in a mile along the "general course," and consequently a rapid current.

Secondly, it flows through a geological formation admirably suited to the purpose; for the beds of the Old Red sandstone are here comparatively level, firm and regular, slowly but surely wearing away under atmospheric influences, at a rate peculiarly adapted to the calculation;* for, if the rock had been much harder, the rate of wear could not have been so well estimated, and if it had been much softer, such a breadth of land would have been worn away that an approximate calculation could hardly have been made.

And, thirdly, the gently-undulating character of the surface of the country enables us to estimate the *amount* of that wear as easily and correctly as could well be.

The chance of error, in the foregoing calculation, can only exist, to any amount worth noticing, in one item, namely, the rate at which the rock of this country is worn away by the river; to determine this, no better example than the one on which the calculation has been made, now exists; although, doubtless, *very exact* observations, carried on for a term of not less than forty or fifty years, on a number of different portions of the beds of rock exposed to the action of the river, might give a more reliable result. I have, however, reason to think that the rate of wear would certainly not be found to be *more*, probably considerably *less* rapid than that of the bed at Wilton Bridge.

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* From all that I have observed, *frost* has little or no effect on the sandstone rock of this country. I have never seen the face of the stone "spalled" or splintered off after frost, as is the case with the rocks of the Oolitic and some other formations, but the wear appears to proceed from a gradual and slow, but certain disintegration of the exposed surface under atmospheric action.

The two other items which form the basis of the calculation, namely, the proportion of cliff exposed to the action of the river at one time, and the whole amount worn away, are open to more precise observation at the present time, and can only be rendered more correct by increasing the number of facts; those however already in my possession are more numerous than are here brought forward, and I am confident that a multiplication of them will only tend to corroborate those given in this paper.

On the Occurrence of Natro-Boro-Calcite with Glauber Salt in the Gypsum of Nova Scotia. By HENRY HOW, Professor of Chemistry and Natural History, King's College, Windsor, Nova Scotia.

The Natro-Boro-Calcite, to which the following communication chiefly refers, must be ranked among the least common of minerals, inasmuch as it has hitherto been found in but one locality, and is not yet fully described in the manuals of mineralogy. The circumstances under which I have lately met with it will add not a little, I think, to the interest it already possesses, as it has been obtained in a new geological position, and in a state of greater purity, than the specimens as yet examined seem to have had; so that I have been enabled to make out its true constitution, which, I believe, for reasons presently to be mentioned, has not till now been arrived at.

The brief history of the mineral is this. It was originally sent, a few years since, to Dr Hayes of Boston, U.S., from Tarapaca, in Peru, where it had been found in the nitrate of soda beds. From the analysis of this chemist, it seemed to be composed of water, lime, and boracic acid, and he called it Hydro-Boro-Calcite. Ulex, however, examined a specimen from the same locality, and finding it mixed with the nitrate and sulphate of soda, he boiled the whole with water for the extraction of these, and, analysing the residue, he expressed his results in this formula,

$$NaO\ 2\,BO_3 + 2\,CaO,\ 3\,BO_3 + 10\,HO,$$

and he named the mineral Natro-Boro-Calcite.

Professor Anderson of Glasgow afterwards analysed a specimen from the same locality, which, though somewhat mixed with foreign matter, he showed to consist essentially of the mineral of Ulex. A few remarks, extracted from the paper containing these results,* will sufficiently mark the characters of the Peruvian mineral, and what is known of the geological nature of its till now unique locality.

"The Natro-Boro-Calcite is found in the nitrate of soda beds of the province of Tarapaca, in Peru, and is known to the natives by the name of Tiza. It occurs in rounded masses, varying from the size of a hazel-nut to that of an egg. Externally these have a dull and dirty appearance, but when broken across, they are found to be formed of a series of interlaced needles of a brilliant white colour, and silky lustre. These crystals were extremely minute in all the pieces I examined, but the specimen analysed by Hayes was composed of prisms a quarter of an inch in length.

The qualitative analysis indicated the presence of boracic and sulphuric acids, lime, soda, water, siliceous sand, and traces of chlorine. Ulex found also traces of nitric acid, but that I examined contained none.

The quantitative analysis gave results according very closely with those of Ulex, excepting that, previous to his analysis, he boiled the mineral with water to extract the nitrate and sulphate of soda which he had detected, and which are obviously a mechanical admixture. This was not done in my case, as the analysis was made for commercial purposes, and I was desirous of ascertaining its exact composition as it occurs. Ulex obtained—

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* Proc. Phil. Soc. Glasgow, Feb. 1853.

	Experiment.	Calculation.
Water, . . .	26·0	25·60
Lime, . . .	15·7	15·93
Soda, . . .	8·8	8·82
Boracic acid, . .	49·5	49·64
	100·00	100·00

which numbers agree very closely with the formula,

$$NaO\ 2\ BO_3 + 2\ CaO,\ 3\ BO_3 + 10\ HO.$$

"The conditions under which this substance is found in loose masses in the nitrate of soda beds, give it a peculiar interest in a scientific point of view, and render it highly desirable that we should have full details of the whole circumstances of its occurrence. The district of Tarapaca has been as yet but little explored, but it would appear that it is chiefly volcanic; and it is remarkable that, up to the present moment, boracic acid has never been found abundantly except in volcanic districts."

The rock in which I met with the mineral, in March last, is part of a very extensive formation of gypsum in the western centre of Nova Scotia, and the precise locality or bed of it at Windsor, on the Clifton estate, lately the property of Judge Haliburton. My attention was first drawn to the other mineral I have named at the head of this paper—the Glauber salt—as a curious "stuff," which had attracted the notice of the quarrymen, and which they called "salts." Upon the specimens of "salts" shown to me I at once saw that at least two distinct minerals were present; and procuring sufficient of both from the spot myself, I submitted them to examination. I give the chemical analysis in the first place, and afterwards the description of the minerals and locality.

The Glauber salt was easily separated in a pure condition, and its analysis in the fresh state gave,

Sulphate of soda, . .	44·54
Water, . . .	55·46
	100·00

showing that it was the ordinary mineral,

$$NaO\,SO_3 + 10\,HO.$$

The second mineral reminded me of the Tiza which I had seen in the hands of Dr Anderson, in Glasgow; and a careful selection of pieces being made, it was proved by the following results to be identical with that curious substance. The water was found by gentle ignition; the soda, estimated as sulphate, in a portion of the anhydrous residue from which the boracic acid was expelled as fluoride of boron; the other ingredients in a separate quantity; the boracic acid by deficiency. The whole results were calculated upon the air-dry mineral, which was always employed for analysis, and I obtained from the substance as it occurred,

Soda, ...	8·36
Lime, ...	13·95
Boracic acid, . . .	41·97
Water, ...	34·39
Sulphuric acid, . .	1·29
Magnesia, . . .	0·04
	100·00

numbers which, notwithstanding the high percentage of water, showed me that I really had to do with Natro-Boro-Calcite. Considering the last-mentioned two ingredients as accidental, I treated a portion of selected mineral with *cold water*, washed well with the same, allowed the residue to dry in the air, and, after about ten days' exposure, analysed it. It was perfectly free from sulphuric acid, and gave of the other constituents,

	Experiment.	Calculation.
Soda, . . .	7·21	7·82
Lime, . . .	14·20	14·12
Boracic acid, . .	44·10	44·02
Water, . .	34·49	34·04
	100·00	100·00

The recurrence of the high percentage of water, and the accordance of my experimental numbers, both from the actual and the purified mineral, with the calculated figures, are ample warrant, I think, for the formula which I propose as the true expression for the air-dry Natro-Boro-Calcite, viz.:—

$$NaO\ 2\ BO_3 + 2\ CaO,\ 3\ BO_3 + 15\ HO,$$

which differs from that of Ulex, before given, by five additional atoms of water, which I think it probable were removed, in his case, by the manipulations with boiling water, and possibly by desiccation at 212°. Indeed, I found that when the air-dry mineral was placed in the air-bath at this temperature, it lost, upon separate occasions,

	I.	II.	Mean.
Water =	8·25	7·58	7·91 per cent.,

which, deducted from my total loss above, leaves 26·49 for the amount retained, a number so close to that really obtained by Ulex, 26 per cent., as to leave me little doubt that mine is the true expression. I find also that Hayes* originally gave 35 per cent. as the result of his analysis.

The minerals just described were found in the closest association in narrow cavities partially filled, perhaps two inches deep, forming a kind of interrupted vein in the body of the solid gypsum rock, exposed by blasting, about thirty feet below the surface, and extending horizontally some few feet. The more abundant mineral of the two was the Glauber salt, so far as I observed personally, but the quarrymen told me that at first the other came out in "bowlfuls," but they threw it away. I obtained only a few ounces of the Natro-Boro-Calcite, and perhaps not more than a pound in all was preserved by those who obtained it on this occasion.

The Glauber salt was perfectly transparent on the first exposure, and afforded a remarkably fine instance of the crystalline forms of the mineral. Some crystals which I saw partially effloresced, were at least an inch and a-half in length and breadth. Many masses were penetrated by the most perfect crystals of selenite, of various sizes, separate and in marls.

The Natro-Boro-Calcite was for the most part along with and among the crystals of the Glauber salt; and in some instances the latter seemed to be crystallized on the former as upon a nucleus; or possibly they were in definite combination as a totally distinct mineral; for crystals, which at first were beautifully transparent, would effloresce after a day's exposure or less, become opaque, and, upon being placed in water, show the silky lustre peculiar to the Tiza, while plenty of sulphate of soda was to be found in the water. In other specimens the Natro-Boro-Calcite was alone, in rounded mammillated masses, in the substance of the gypsum; and these, which were of all sizes up to that of a pigeon's egg or larger, on being broken, presented the appearance of a finely-fibrous, silky lustrous mass, brilliantly white in colour.

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* Liebig und Kopp's Jahresbericht, 1849, p. 780.

The purest pieces had a specific gravity of 1·65; hardness = 1; were tough between the teeth, tasteless, scarcely soluble in water; before the blowpipe melted with ease to a transparent head.

On comparing the circumstances of this occurrence with those referred to in the remarks of Professor Anderson, before quoted, and some other facts, I think they are very interesting. In the gypsum of Nova Scotia, we have a new and distinct locality for the rare mineral Natro-Boro-Calcite, which is analogous with that of a species chemically allied,* boracite, *e.g.*, $MgO\,BO_3$, being found in the gypsum of Holstein, and a compact boracite forming beds with rock salt and gypsum at Starsfurth in Northern Germany.

With these exceptions, boracic acid is found, as is well known, either in directly volcanic regions, most abundantly as such, or as borax; and a recent well-marked case of actual sublimation of the acid from a volcano in the Island of Vulcano, near Sicily, has been studied by Warrington,† or in smaller amount in minerals the products of recent or extinct volcanoes, as Humboldtite,‡ from ejected blocks of Vesuvius and Zeolites, and Datholite from trap of Salisbury Crags, New Jersey, and other places, or in minerals of purely plutonic or metamorphic rocks, as Tourmalines, the Rhodizite of Rose, and Axinite; the species which contain it at all being few in number. It may be noticed, also, that traces have lately been met with[*] in the Kochbrunnen of Wiesbaden and the Kaiserquelle of Aachen.

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* Nicol's Mineralogy, p. 305.

† Well's Annual, 1856, p. 232.

‡ Nicol's Mineralogy, p. 307.

If, now, we may reason from the character of the majority of its situations, we may almost consider the volcanic or at least igneous origin of boracic acid so well established as to be led, by its occurrence in the saliferous strata, to seek for some volcanic agency as the cause of their production.

Such an origin, I find, has already been assigned to the gypsum of Nova Scotia by Mr Dawson.[†] This formation has been shown to be a member of the lower carboniferous series, and is assumed to have been produced by the action of rivers of sulphuric acid, more or less dilute, such as are known to exsist[‡] in various parts of the world, issuing from these active volcanoes, and flowing over the calcareous reefs and bed of the sea. " In accordance with this view, the gypsum is found only in association with the marine limestones, though, as might have been anticipated, these last sometimes occur without any gypsum."[§]

Gypsum, which is geologically of various ages in different countries, was supposed by the writer just quoted to be peculiar to the lower carboniferous series in Nova Scotia alone, but it has been recently shown by Professor W. B. Rogers[‖] that a bed of this substance, with rock salt, occurs in a thick deposit in limestone of the same period near New River, in Virginia, in the Appalachian belt.

I think the occurrence of Natro-Boro-Calcite in the gypsum of Nova Scotia cannot but lend support to the theory of Dawson as to the origin of this rock, when all the circumstances above mentioned are taken into consideration, and that a search for it, or some equivalent in similar situations, might lead to more conclusive evidence as to the geological causes of the saliferous systems in general, and furnish additional links of union between the sciences of geology and mineralogy.

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[*] Liebig und Kopp's Jahresbericht, 1852, p. 328.

[†] Acadian Geology, p. 223.

[‡] Lyell's Elements, chap. xvi.

[§] Acadian Geology, p. 224.

[‖] Edin. New Phil. Jour., April 1857, p. 360.

On the Cause of the Pyramidal Form of the Outline of the Southern Extremities of the great Continents and Peninsulas of the Globe. By W. L. GREEN, Esq. of Honolulu, in the Island of Woahoo, Sandwich Islands.

Humboldt, in his "Cosmos," remarks: "The pyramidal configuration of all the southern extremities of continents belongs to the *similitudines physicæ in configuratione mundi*, to which Bacon already called attention in his "Novum Organum;" and again he observes, "The pyramidal terminations of the great continents are variously repeated on a smaller scale, not only in the Indian Ocean, and in the peninsulas of Arabia, Hindustan, and Malacca, but also, as was remarked by Eratosthenes and Polybius, in the Mediterranean, where these writers had ingeniously compared together the forms of the Iberian, Italian, and Hellenic peninsulas."

A glance at the map of the world renders the truth of the above obvious; indeed, it will be seen that there is no considerable portion of land throughout the whole globe but what does terminate towards the south in one or more pyramidal forms.

The cause of this fact may be expressed (as I would suggest) in a few words, viz., that when an arched or conical surface enters the water at an angle, in the direction of the length, the water line must always describe a conical figure thereon, with the apex pointed to the deflected end.

In the application of this fact to the case in point, it will readily be perceived that, as a rule, the surface of every continent or peninsula partakes more or less of an arched or a conical form,—that is to say (independently of its arched form as a portion of a spheroid), it is higher towards the centre than at the sides, and the incline from the interior towards the sea-coast is moderately regular.

There is no fact in geology better established than that vast portions of the earth's crust are constantly undergoing a change of level. The great area in the Pacific Ocean occupied by atols and coral islands is perhaps the grandest and best proved instance of this fact. These atols also prove, as has been ably demonstrated by Darwin and Dana, that the nature of the subsidence or upheaval is not necessarily a simultaneous ascent or descent of the whole area, but rather that a large segment of the earth's crust remains stationary, or nearly so, at one end, and rises or falls at the other.

It is self-evident that the largest and deepest oceans are the areas of greatest subsidence, and that the southern hemisphere, consisting as it does of nearly all ocean, has been the grand area of subsidence. If, then, the axis of this area of subsidence (or of these several areas of subsidence) has been anywhere to the northward of the pyramidal extremities of South America, Africa, Arabia, Hindustan, and Malacca, that form of coast line follows as a necessary consequence ; for they are arched or conical surfaces, entering the ocean at an angle in the direction of their length ;* and they have their apices pointing to the deflected end.

What the Southern and Indian Oceans are to these countries, the Mediterranean is to the peninsulas projecting into it ; the Atlantic to Greenland, Newfoundland, and the south-west of England ; and perhaps North America may owe its form to the same principle.

It is immaterial to the truth of this principle whether any of these particular countries be at present rising or falling, all that is necessary is, that an area of the earth's surface, of more or less arched or conical superficies, enters the sea, or emerges from it at an angle.

A simple practical exemplification of the principle is obtained by taking in the hand a common playing card, and arching it slightly by pressing the two sides ; insert it in a basin of water with the arch uppermost, and the lower edges just below the surface, the greater part of the arch being above ; then depress one end just below the surface, and the water line will form a good representation of the southern extremities of South America, Africa, or Hindustan, according to the angle of depression. By bending the card along the middle, thus forming a ridge in the centre with straight sloping sides, and depressing one end in the water as above, similar figures are produced; or, bending the card parallel to its length, about three-fourths of an inch from one side (the ridge thus formed representing the position of the Andes to South America), and depressing one end below the surface of the water at a certain angle, an exact representation of the southern extremity of that country is formed by the water line.

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* It is hardly necessary to call attention to the fact, that all the main mountain chains of the portions of continents where the pyramidal form exists run north and south, or nearly so,—that is to say, the arched or conical superficies enter the ocean at an angle in the direction of their length.

The smaller the angle at which such a surface enters the water, the more acute will be the conical figure, and *vice versa.* This agrees with the facts as shown in the three countries just named; inasmuch as where we find most ocean, there we should expect the greatest depression, and the surface of the land to enter the ocean at the greatest angle. Thus to the southward of Hindustan there is more ocean than to the southward of Africa, and the angle of the conical figure of the former is consequently more obtuse than that of the latter; whilst to the southward of Africa there is more ocean (and probably, therefore, more depression) than to the southward of South America, and the angle of the coast lines is more obtuse than those of the last-named country, which are the most acute of the three, and, having the least area of ocean to the southward, may be expected to be inclined to the ocean at the smallest angle.

The bluff point of Africa is evidently a local result, arising from the circumstance of there being a table-land there, and is rather a corroboration of the truth of the principle now advanced than otherwise, for this is just the effect a table-land would have under the circumstances supposed.

It is of course not to be expected that we should find perfectly conical or pyramidal coast lines in these countries, as local elevations, subsidences, and degradations destroy the regularity of the surface, which has a corresponding effect on the regularity of the coast lines.

The general average height of the land above the sea-level should, on this principle, decrease not only from the central portion towards the sides or coasts, but also from the direction of the supposed highest end of the area towards the lower, —from the northern base of the pyramid to the apex at the south; and this seems to be actually the case. The extensive and high table-lands appear to be where they should be in South America, Africa, and Hindustan. Volcanic peaks must not be accounted in estimating these relative heights; and even mountain ranges not volcanic, which may have been raised subsidiary as it were to the grand movement, can only be expected to show a partial agreement with the principle.

The general course of the rivers should show a tendency to flow towards the deflected end of the area, besides running east and west from the crown of the arch or ridge; and in accordance with this, we find a marked southerly trend of the rivers in the conical portions of South America, Africa, Hindustan, and in the great track to the southward of China, ending in the peninsula of Malacca.

It may be observed, that when a table land of unusual height extends across an area, thus entering the ocean at an angle, the coast line would necessarily make a sudden curve in at the point where it ended. This may perhaps account for the deep bights on each side of South America, and on one side of Africa.

The subsidence exhibited by the ocean at the north polar regions, being a comparatively small circular area of depression in a mass of land of somewhat even character of surface, would necessarily not admit of larger pyramidal outlines of land than capes and promontories.

Although the proved nature of the subsidence over the large area of atols in the Pacific Ocean,—that is, stationary at one end and depressed at the other,—is brought forward to show the probability that this may be the nature of all the subsidences and upheavals of the earth's crust on a grand scale; the certainty of the fact, that a conical or arched superficies entering the sea-level at an angle must present a conical or pyramidal outline where the water cuts it, ought rather, in view of the phenomenon that all the great continents or peninsulas (being conical or arched surfaces) point with their apices to areas of subsidences, be the proof that such is the mode of that subsidence or upheaval.

General Considerations relating to the Earth's Crust, which seem to occur from the nature of its Subsidences, as exhibited by the form of the Southern Extremities of Continents; also their probable connection with Volcanoes, illustrated by Kilanea.*

Confining our view, for the present, to the southern half of the globe, as divided by the equator, it will be evident (if the cause of the form of the southern extremities of continents be considered as demonstrated) that the whole solid crust of the southern hemisphere is inclined at an angle to the surface of the true spheroidal form of the earth; or, at any rate, it is so from the equator to some parallel of latitude to the southward of Cape Horn, say at least to 60° south.

But besides this inclination, there is another general form, which the surface of the solid crust in this hemisphere must have (between the equator and 60° south), judging from the facts as we find them.

If we commence from a point on the equator where longitude 25° west cuts it (being about the centre of the North and South Atlantic Oceans,) and draw a straight line (on the globe) to a point in latitude 60° south and 35° east longitude, that is to say, 60° south and 60° to the eastward; from this point another line to a point on the equator, 60° northward and 60° eastward; thence 60° southward and 60° eastward again, and so on round the globe, till we arrive at the point from which we started; we have in the spaces included in these lines six regular triangular areas, each of 120 degrees base. In three of these spaces we find nothing but ocean, and in the other three all the land in this portion of the globe pretty equally divided; the sea spaces and land spaces being also alternate, that is to say, there is an area of all ocean between each triangular area containing the land. And further, if we include in our view Madagascar with Africa, and New Zealand with Australia, we find the apices of the cones formed by the coast lines point to about the southern angle of the three imagined triangular areas containing the land; or, in other words, we ought to look for the central ridge of the conical superficies in or near the line drawn through the centre of our land areas. The three meridian lines, which in fact equally divide our triangles containing the land, pass within three degrees of the Northern Andes, through the great north and south chain of Southern Africa, and within three degrees of the New South Wales and Van Diemen's Land range of mountains. That is to say, they pass close to the three, and the only three, great north and south ranges of the southern hemisphere. Or, taking the six meridian lines at equal distances of 60° each, which divide our six triangular areas, it may be affirmed, speaking generally, that three pass along the highest ridges of land, and three along the central or deepest portions of the ocean, in the southern hemisphere; a line of ridge and a line of hollow being alternate and at equal distances.

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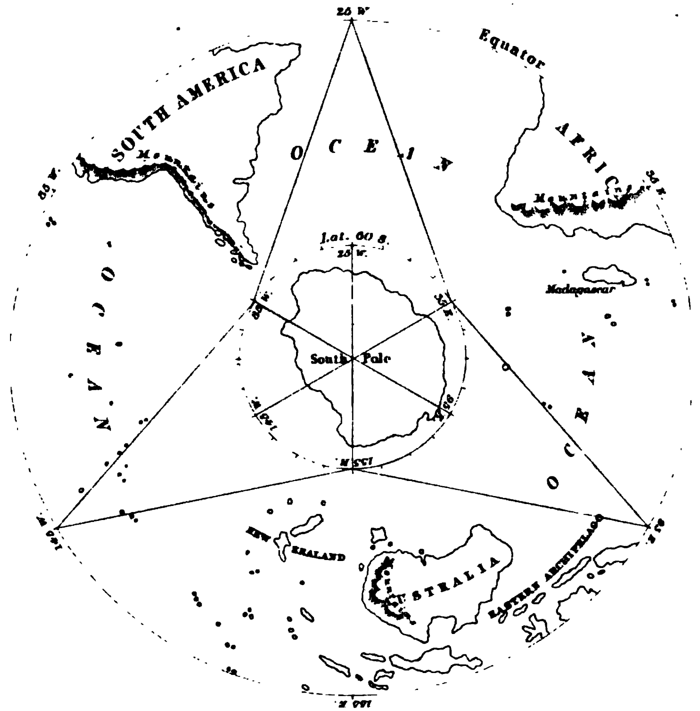
* Some of these considerations are merely speculative; and although they depend mainly on the truth of the view taken of the form of the southern extremities of continents, they may be wrong; but the truth of that view is in nowise dependent upon these speculations.

It is easy to perceive, by inspection of the accompanying sketch (Pl. I., fig. No. 1) of the Southern Hemisphere, showing these triangular areas, that a section of the globe taken through any parallel of latitude between the equator and 60° south would exhibit on the surface-line of the solid crust a figure approaching that in fig. No. 2 (Pl. I.), which is supposed to be a section taken through the tropic of Capricorn, exaggerated in proportions to be rendered more clear and sensible.

It seems hardly necessary to observe, that this general view of the facts of the form of the earth's crust in the southern hemisphere is more compatible with the hypothesis of a solid crust, shrinking on to a contracting fluid interior than with any other hypothesis advanced. It must be left to mathematicians to say whether a supposed equal force, acting upon every point of a hemispherical crust of supposed equal strength, would not be resolved into three directions, and tend to cause six rents, as supposed in fig. No. 2 (Pl. I.); and whether the irregular hexagonal form, that is with the alternate angles interior, is not the form that ought to exist under the circumstances supposed.

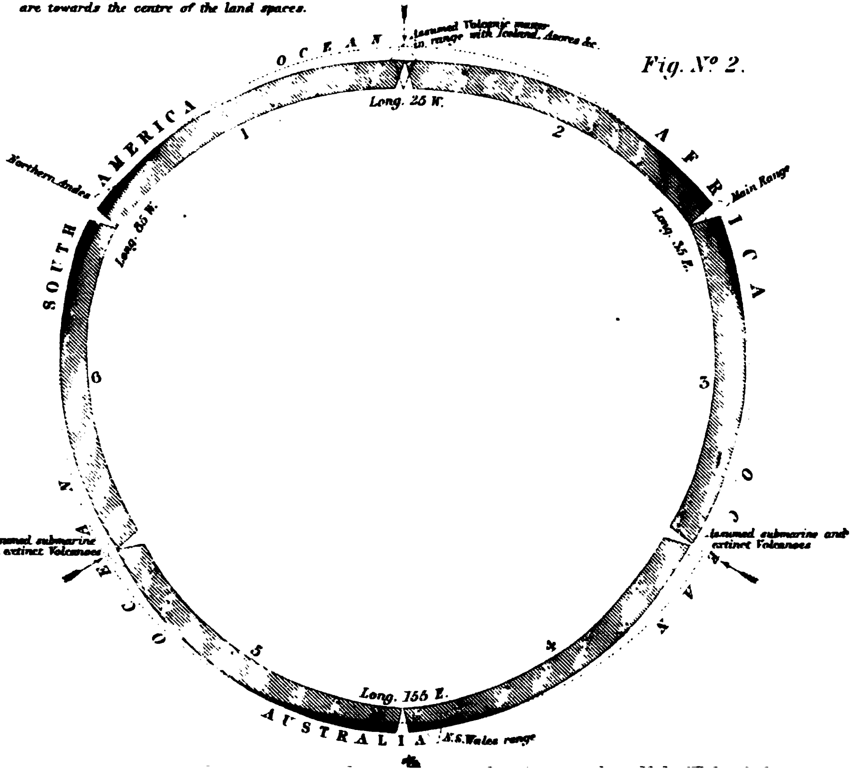
There is one result of an equal pressure on the hardened crust of a spheroid which does not require a mathematical calculation to be perceived to be a necessary one,—that is, that the flattened poles must, other things being equal, be the

Fig. Nº 1.



THE SOUTHERN HEMISPHERE *supposed to be divided into six equal (reckoning the bases by degrees) triangular spaces, shewing that in three is all the Land, and three contain nothing but Water, and that the main ridges of the land are towards the centre of the land spaces.*

Fig. Nº 2.


OCEAN
Assumed Volcanic range in range with Iceland, Azores &c.
Long. 25 W.
1
2
SOUTH AMERICA
Northern Andes
Long. 85 W.
AFRICA
Main Range
Long. 35 E.
6
3
OCEAN
Assumed submarine and extinct Volcanoes
OCEAN
Assumed submarine and extinct Volcanoes
5
4
Long. 155 E.
AUSTRALIA
N.S.Wales range

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OF
CALIFORNIA.

first to yield. Is there evidence that the poles of the earth have so yielded first, and now exhibit the greatest depression? The circular space of ocean existing as far as we can penetrate at the North Pole, shows, at any rate, a certain amount, and a regular amount, of depression there.

The Antarctic continent at the south is as yet no evidence that the depression of the solid crust, now assumed to be proved to exist in an increasing degree from the equator to 60° south, is not still greater between this parallel and the South Pole, inasmuch as all that land is, as far as known, purely *volcanic*. It is a part of the view now advanced of the nature of the depression of the earth's crust, that there will probably be an outbreak of the molten interior at the central portion of the line of depression. It is to be expected (as an inspection of fig. No. 2 (Pl. I.) will explain), that a rent will be formed in the solid crust at the points or lines of the resolution of the depressing forces. The molten interior, then, may flow out to the height due to the pressure (modified by accompanying accidental circumstances), it may solidify, thicken the crust about that region, and show above the ocean as land; but is no proof whatever of the bodily rise or non-depression of the mass of the solid crust of the earth,

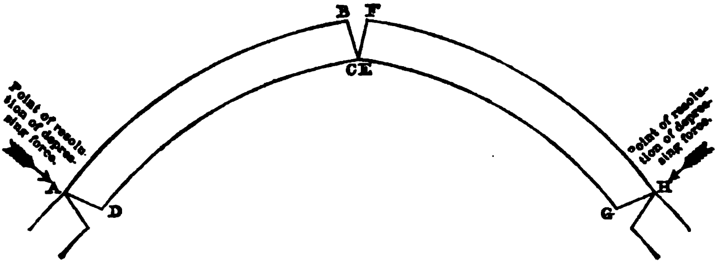
A notable instance of a line of purely volcanic matter, and no other land whatever, along a line of depression (in accordance with this view), is exhibited by Iceland, the Azores, Cape de Verde, Trinidad, and Sandwich Land, extending from the Arctic to the Antarctic circle, and all included within about ten degrees of longitude. The central meridian of this space, 25° west, was the starting-place for our six lines, and goes through the centre of the first of our areas of subsidence in the southern hemisphere.

Whatever laws have governed the form of the solid surface of the southern hemisphere must, we may be satisfied, have also governed those of the northern; and if we cannot equally well apply the same to both, it is because some modifying cause, not understood, has altered or complicated the effects. The simplicity of the observed facts of the case in the southern hemisphere, and their comparative complexity in the northern, ought to induce us to confine our attention to the former first, resting assured that, when these are brought under law, the facts of the northern hemisphere must some day be included.

It has been shown, principally through the admirable expositions of Darwin, that lines of active volcanoes are generally found on areas of upheaval, or at least that, where volcanoes are active, there the land is rising: that on areas of known subsidence, active volcanoes are not found. This is principally exemplified in the Pacific Ocean, where perhaps an equally correct statement of the case might be expressed as follows, viz.:—that active volcanoes, and narrow areas and lines of moderate upheaval, in the Pacific Ocean, are found on the borders of areas of subsidence, and no active volcanoes within them.

On the principle now advanced, of subsidences of large areas of the earth's crust at one end, from a comparatively stationary axis at the opposite end, the above circumstances would seem to result as a matter of necessity. Referring again to a portion of the earth's crust, in the form supposed to exist in the section through the tropic of Capricorn (fig. 3), it will be

Fig. 3.


B
F
C
E
Point of resolution of depressing force.
A
D
G
H
Point of resolution of depressing force.

seen that the effect of the mutual pressure which must exist amongst the segments is to cause an upheaval at the sides opposite to the depressed sides. Suppose A, B, C, D, and E, F, G, H to be any two of such six segments, or any two of any number of segments extending round the earth, with their sides mutually resting on each other, it will be evident, on inspection, that any force which acted so as to depress the segments at A and H would tend to raise them at B and F. The rents between all these segments would, we might expect, be filled with the molten interior, and volcanoes or eruptions of trap might exist along the lines of rent. The volcanoes along the rents of upheaval might well be active; for we can perceive no reason why they should not be; those along the rent of depression would be extinct; because this would be the natural effect of submerging an active volcano for centuries in the depths of the ocean. The water would have access to cool and solidify the molten matter in the rent. Were the greatest active volcano in the world, Kilanea on Hawaii, to be submerged, together with the whole island, to the depth of one mile below the surface, we can imagine the effect a few thousand years might have upon it; but with Kilanea one mile below the surface, Mannakea would still exist above it, an extinct volcanic island 4000 feet high. Such extinct volcanic islands are commonly found in the central portions of oceans, or in the central lines of areas of depression.

The low line of volcanoes, active and extinct, in the Sandwich Islands, is situated upon a line of upheaval between two areas, one of known subsidence (the old region), and one of deep sea (assumed subsidence). The principal active volcano, Kilanea, is unique in the phenomena it presents; nor can they be accounted for on any theory hitherto advanced as to the moving cause in volcanoes generally. The only supposition approximating to probability, in the case of other volcanoes, viz., that of the waters of the ocean obtaining access to the molten interior, here fails. There is no outburst of steam, vapours, or gases whatever. The greatest amount of vapour that is ever seen or noticed in any way may be fully accounted for by the rills of fresh water which may percolate amongst the heated rocks. Nothing is seen but a comparatively quiet unfathomable lake of liquid stone. This great lake has its tides, which rise or fall hundreds of feet with fearful calmness. The greatest eruptions are the quietest; thousands of acres of land may be covered hundreds of feet thick with the molten lava, and the inhabitants a few miles off know nothing at all about it. If the rise of such enormous masses were caused by expanding vapours, we ought to see or hear something of them now and then. The roar of the escape of the steam which could produce such tremendous mechanical effects as are constantly produced on Manua Loa, would be heard over the whole group; and it would surely sometimes escape after doing its work. No such instance has ever been recorded. I do not hesitate to say that steam, vapour, or gases, are no more the cause of the great movements of the lavas on Hawaii than the dust which accompanies the movement of an army is the cause of its march. In this, as probably in other volcanoes, and as in thousands of other instances, cause and effect have been confounded.

The great rises and falls of molten matter in the rents of the earth which are or may be open to the surface on Manua Loa, may perhaps be looked upon as simply the varying height of a column of liquid matter connected with the liquid interior, depending on the pressure of the nearest segments of the earth's crust on that interior, modified by the temperature, and constant liquidity or viscidity, by the varying amount of the pressure of the atmosphere, and by the form, perhaps a varying one, of the communicating rent or orifice. As we find a steady succession of outpourings have occurred for many ages past, and as we know that a steady subsidence of an adjoining area of the earth's crust has also being going on during the same time, may not a succession of minute subsidences of a segment, as above supposed, have been the primary cause of corresponding small rises in the column of lava and of the consequent regular overflows?

As J. D. Dana, the Geologist to the United States Exploring Expedition, and the last person who, I believe, has scientifically inquired into the causes and phenomena of this volcano, advances with considerable detail and ingenuity the opposite opinion to this; that is, he argues that the rise of the lavas is due to the steam, vapours, or gases arising from the access of fresh water to the column of lava in the rent or conduit; it may be necessary for me to state my view of the causes of the principal phenomena which he attributes to the action of expanding vapours.

And first, with respect to the "boiling motion" in the great lake; "the flow of the lavas in an unceasing current to the south-west," he observes of it, "the steam is seen to move on at a rate which has been estimated at three and a half miles per hour." This motion he agrees with Mr I. Coan in comparing to that of a boiling cauldron; for he says "it can be nothing else." That there may be a certain amount of vapour escaping from this lava, arising from the access of fresh water to portions of the column near the surface particularly, is not improbable; but that this constant, regular, and steady motion in one direction is caused by such escaping vapours may well be doubted.

I would suggest, whether the cooling of the exposed surface of this molten lake would not cause the cooled, and consequently heavier, portions to descend (as in water), to be replaced by the hotter and therefore specifically lighter portions, from the comparatively inexhaustible supply of the molten interior. This action might, and probably would, assume the form of a current, the direction of which would depend upon the form of the sides of the conduit. The different angle of inclination of the sides, for instance, might easily be supposed to produce a surface current.

The other remarkable phenomenon, for which it seems at first sight extremely difficult to account, is this; that whilst the probability is, that the conduits of Kilanea and of Mokuweoweo (the summit crater of Manua Loa) must unite at some depth beneath the surface, both being filled with a liquid, the column of lava in the latter often stands nearly ten thousand feet above that of the former, without even sensibly affecting its height or action.

Dana supposes that the lava in one column may be more inflated with vapours and gases than that in the other; and therefore being, on the whole, specifically lighter, a longer column would balance a shorter one.

Without pretending to say that this inflation may not exist to a certain extent in the upper portions of the column, and therefore have some partial effect, I would suggest another cause, which seems to require no supposition, but what must be a necessary result of the facts of the case.

The sketch given in Dana's work represents a section of Manua Loa, showing the proportionate slopes and distances on the surface, and the width of the craters of the two volcanoes, all according to scale, as determined by the officers of the Expedition. The lines representing the sections of the conduits are of course imaginary, but may fairly be expected to give a probable representation of their form.

There can be little doubt that the conduit of the summit crater (being the main and the largest crater, and the effects resulting from it having vastly exceeded those of Kilanea), is also much the larger of the two. Now, in two conduits supposed to be connected, with the same heated liquid mass of fixed temperature, the temperature in the wider one would, other things being equal, be higher than in that of the other, in proportion to the squares of their diameters, or in the proportion of the mass to the amount of cooling surface.

The rest follows of necessity from this fact, which is also a necessity. A column of cold water will balance a longer column of hot water where the difference in temperature is only perhaps 150°, how much more, then, must we expect a column of molten lava of certain temperature to balance a longer one of a temperature higher perhaps by 1000°. But besides the actual difference in specific gravity which must exist in the lava of the two columns, we must in this case take into account the increased viscidity of the lava as the temperature is lower; that is to say, a pressure on the base of the cooler and more viscid column, that would not sensibly affect its height, on account of this comparative viscidity, might raise the hotter and more liquid one a considerable height. According as a liquid loses the theoretical properties of a liquid, or becomes viscid, so it is less amenable to the theoretical laws of liquids. Water itself is not a theoretically perfect liquid, and in many practical cases, from the cohesion of its particles, is not governed by the theoretical rules. How much less, then, may we expect lava to be so. The difference in the friction of the ascending hotter currents in two conduits of different diameter, must be an important effect to be added to the two already mentioned in causing a greater relative reduction in the temperature of the lava in the narrower one.

These principles, as it appears to me, explain easily and naturally this the most anomalous phenomenon in the eruptions of Kilanea and Manua Loa.

It will be seen, first, that the column of lava in the summit crater conduit may *always* stand many thousand feet higher than in that of Kilanea, and yet never be visible, or its effects be apparent, either in the crater or on any part of the mountain. An outbreak, therefore, may occur through the sides of the mountain, far above the level of Kilanea, without having any other effect on the latter than perhaps *lowering it.* It is "the last hair that breaks the camel's back;" and a very slight rise in the column may rend the mountain, already and for some time in a state of tension. Still, as before explained, a considerable rise may take place in the lighter and more fluid column of the greater conduit without sensibly affecting that in the smaller. There can be no doubt that there ought to exist a certain amount of correspondence between the movement of the lava in the two columns, however different the actual height; but how are we able to detect it? The surface level of the summit column is always far out of our sight, except in a few fitful moments, when it rises to the bottom of the crater. Or if, judging from an outburst through the sides of the summit, we suppose the level to have risen, and hasten to Kilanea to observe the effect, we find it lower than when we last saw it. The outburst at the summit of Manua Loa has lowered the column in that conduit, and that in Kilanea may have fallen in consequence. The nature of the case supposed —the lava in one column being invisible—renders it all but impracticable to detect the correspondence of movement in the two conduits.

The eruptions in this mountain are far less noisy, and accompanied with fewer circumstances to astonish the senses, than in most instances, because, no doubt, as Dana says, the lavas are far more liquid, and the vents are open. *There are no means of confining or entangling elastic vapours,*—effects which probably are merely incidental to, and the results of, the rise or overflow of vast masses of molten rock in all volcanoes, not their causes.

Dana asks, Why are the lavas of Hawaii more liquid than those of most other volcanoes? He tries the fusibility, and finds it no greater (if so great) than that of other lavas, and leaves the question unanswered. The conduits, from the source of the lava, are wider, judging from all the observed circumstances than those of any other known volcano. I have already, shown that, under such circumstances, the temperature would necessarily be higher, and consequently (*cæteris paribus*) the liquidity greater than in any volcano with a conduit of less diameter.

Were we at a loss to account for the great rises of the lavas on Hawaii, without having recourse to the supposition of elastic vapours, it will be pretty evident, from what has been said, that any cause which produced a change in the relative temperature of the two columns might produce a considerable amount of variation in their height. That elastic vapours are not the cause of these great rises, as supposed by Dana, I have already offered some considerations; and, in conclusion, I may recapitulate:—There are no evidences or appearances of the escape of any such amount of elastic vapours as would be at all commensurable with the tremendous effects produced. No violent escapes, or explosions of steam on a large scale, are noticed. The lavas that overflow are usually found to cool compact and solid; few or no vesicles of entangled gases occur, except in the mere scum of the lakes or pools, or in the agitated surfaces of streams subject to varied and irregular mechanical forces. All the most important phenomena and motions can be better accounted for in other ways.

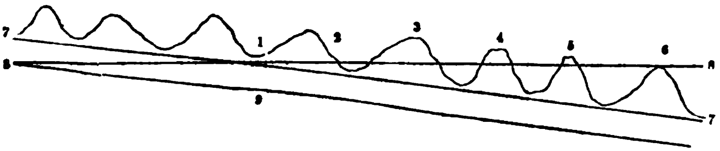
It may be observed, that Dana expressly excludes the waters of the ocean from being considered the probable source of the vapours; and in this we agree. The vapours from the water of the rills derived from rain, are the only ones he brings forward as likely to have any connection with the lavas of the volcano. Now, it is probably far within the truth to say (and an approximate calculation within certain limits may be made), that the whole annual rain-fall over one hundred square miles on Manua Loa might easily be evaporated from the heated surface of rock round the circumference of the conduit of Kilanea, from the top down to the sea-level, only in one fortnight. Further, were it all by some means accumulated, and let on at once, around the sides of the conduit, it is difficult to imagine how the resulting steam could affect, become entangled with, or exert an efficient pressure on, the column of lava. By whatever orifices the water entered, the steam could escape; and supposing, in the worst case, that all these orifices were filled with water, the elastic vapour would have a column of lava on one side, and a column of water on the other. *A column of water double the height of that of the lava would be blown into the air before affecting the height of the column of lava one inch.* This consideration may also help to dispose of the effects of a percolation of water from the ocean on a column of lava standing far above its level.

The most important feature in this view of volcanoes appears to be, that they may be the results of the movement of the crust of the earth rather than the causes of it—the latter being an idea which seems to influence too powerfully many geologists.

It is not difficult to perceive that, taking into view the general shape of the crust of the southern hemisphere, as here assumed to exist, that a powerful lateral pressure must be the result of, and coexist with, the downward pressure in each segment, and that other mountain chains *might be formed in each, by this lateral pressure* (*besides the central ones*). And, further, as the subsidiary forces or effects would tend to be developed in the same relative portions of each segment; in accordance with this we find the summits of smaller mountain chains, bearing a very similar relative position and distance to the main ones, in three relatively similar segments, viz.,—in the Falkland Islands to the Andes, Madagascar to the ranges in Africa, and New Zealand to that in Australia.

The straits between and about Tierra del Fuego and the main land, and between Australia and Van Diemen's Land, are the necessary results of the first hypothesis advanced; that is to say, a chain of mountains entering the ocean, or emerging from it, at an angle, must leave the last one or two peaks surrounded by water, thus:—

Fig. 4.



1. Passes lowering. 2. Promontory. 3 and 4. Islands. 5. Rock. 6. Shoal. 7. Sloping Plain. 8. Sea-level, giving a conical form to the coast-line of plain land. 9. Inclination of the whole surface of crust.

A similar effect is visible at the points of pyramidal outlines of land all over the world.

It follows also on this view of the movement of segments of the crust of the earth, that upheaval and depression might, and probably would, coexist; that is to say, that whilst, for instance, the chain of the Andes was being raised by lateral pressure, the portion of the segment on which the Andes are situated, may be falling at the southern end. The actual rise or fall, then, of any particular spot would depend on the rate of upheaval arising from lateral pressure, compared with the rate of depression at one end, and the distance from the stationary axis.

It will thus be seen that one simple force gives rise to two comparatively simple movements; but the visible effects of these two simple movements may often appear extremely complicated from one point of view,—that is, judging as we do from former ocean-beds or shores. Within a comparatively small area a varied rate of upheaval, a varied rate of depression, and stationary land, might exist, all caused by one force and two movements.

Another effect, which must always complicate appearances in our inquiries into the actual motion of the earth's crust, is the alteration of actual sea-level which every rise or subsidence throughout the whole globe must produce. And this must in many cases be important in amount. Suppose, for the sake of illustration, that the enormous subsidence of the Pacific area, pointed out by Darwin and Dana, had been the only grand movement of the earth's crust in recent times, or since the tertiary epoch, it must have lowered the level of the ocean over the whole globe between 400 and 500 feet. This would have been alone sufficient to drain the waters of the sea from off a large portion of all the tertiary basins in the world, without these areas having undergone any upheaval whatever. It is not pretended that this has been the case, but is brought forward to show how such evidences of subsidence and upheaval must necessarily be complicated and uncertain.

It seems probable, from a due consideration of the form and direction of different areas of the earth's crust, as here supposed to exist, that the greatest depth of the ocean may have been under-estimated; for, taking the double slope (that is to the southward, and also east or west) from the highest tablelands of South America or Africa, to the level of the sea, and imagining the same slope continued under the ocean, as far as we can go south-eastward or south-westward towards the central line of the ocean without coming upon the base of the volcanic land, 40,000 to 50,000 feet seems to come within the bounds of the probable depth. Somewhere in the Southern Ocean, between latitudes 45° and 60°, at about equal distances between Cape Horn and the Cape of Good Hope, that and Van Diemen's Land, or the latter and Cape Horn, will probably be found to be the deepest portions of the ocean. In sounding for greatest depths, care should be taken not to get in the line of the volcanic islands.*

Although only indirectly connected with this subject, it may be well to call the attention of ethnologists to the corresponding circumstances of the correspondingly peculiar tribes which exist at the southern extremities of the continents of America and Africa, and perhaps of Australia or Van Diemen's Land, and that the anomalous circumstances may be connected with, or perhaps accounted for, by the subsidence (in one case, or upheaval in another) of their end of the continents.

Darwin, in his "Voyage of a Naturalist," speaking of the Fuegians, says, "Whilst beholding these savages, one asks, Whence have they come? What could have tempted, or what change compelled, a tribe of men to leave the fine regions of the north, to travel down the Cordillera or back-bone of Ame-

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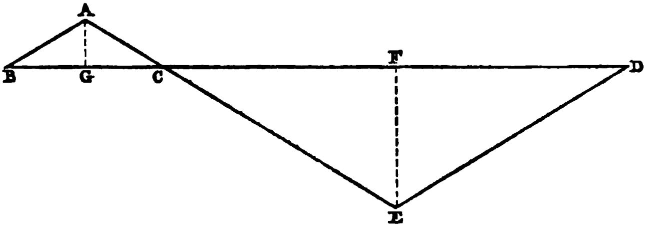
* A fair view to take in estimating generally the probable greatest depth of the sea, all other means failing, seems to be, as explained in the following sketch.

Fig. 5.



Draw any triangle with two equal sides (A, B, C), prolong the base, and make the line C D bear the same relation to B C that the area of the sea does to the area of the land (say three times the length). Bisect C D in E, and draw F E perpendicularly to C D. Extend A C to E, and join E D, F E will represent the probable proportion of the deepest depth of the sea to A G, the greatest height of the land. Call the highest table-lands (before degradation), 15,000 feet, the depth of the sea (after allowing for sediment), would be 45,000 feet.

rica, to invent and build canoes, which are not used by the tribes of Chili, Peru, and Brazil, and then to enter on one of the most inhospitable countries within the limits of the globe?"

Well may he ask this question; and perhaps the answer may be—They have never done so. But rather, being once, when the southern extremity of this continent was at a less angle, the inhabitants of a plain region at the base of the chain of the Andes, a rising ridge on a falling area, when broad lands may have existed on each side of them, and when, consequently, the climate was drier and warmer, the soil better, and its productions abundant; their dwelling-place has, through the course of unmarked ages, gradually, and to them insensibly, subsided into the ocean. Their descendants are left at last, on the narrow bases of the ridge, in a raw, moist climate, barren soil, and with a deep and stormy strait between them and the main land, now contracted and fully occupied by its own tribes; the necessity of the case compels them to invent canoes, and obtain their subsistence by fishing. The alteration and inferiority of circumstances induces a corresponding alteration in their physical appearance and condition. Thus, although at the present day they are classed amongst the lowest grade of savages, "their features indicate relation to the Araucans," a far superior tribe, "whose neighbours they are."*

As the subsidence of vast archipelagoes will account for otherwise inexplicable circumstances in the existing facts of the Polynesian race,† so may the subsidence of continents account for anomalies in races of men in all regions of the globe. No study is more likely to throw light on some of the most notable phenomena of organized beings than that of the latest movements of the crust of the earth, and the relation of the sea to the land. In this instance, the peculiar cause, the peculiar food, and the degraded state of the Fuegians, may be necessities imposed upon them by the laws of the cooling of the planet on which they reside.

HONOLULU, *January* 16, 1857.

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* Prichard's Natural History of Man, 447, Ed. 3.

† See Sandwich Island Magazine, No. I., Art. 2.

Observations on British Zoophytes. By THOMAS STRETHILL WRIGHT, M.D., Fellow of the Royal College of Physicians, Edinburgh.*

Description of Plates II. & III.

Clava.

Fig. 1. Corallum and polyps of *Clava repens* (magnified three diameters).
2. Clava membranacea (natural size).
3. Corallum or polypidom of *Clava membranacea* after removal of polyps by maceration (enlarged).
4. Portion of corallum of *Clava cornea* (from Professor Goodsir's specimen; enlarged).
5. Diagram of reproductive capsules or polyps on female polypary of Clava—*a* ectoderm—*c* endoderm—*ac* generative cavity—*d* nutritive cavity of pedicle and capsules—*e* ova, changing to (*f*) ciliated planarioid larvæ.
6. Free swimming larvæ.
7. Reproductive capsule of female *Coryne glandulosa*, lettered as fig. 5, and showing the origin of the ova (*c*) from the external surface of the endoderm.

Eudendrium.

8. *Eudendrium pusillum* with Medusa-buds (eight diameters).
9. Medusoid of do. with tentacles relaxed.
11 & 12. Ideal figure of Hydractinia as a Gymnopthalmatous Medusa, and figure of ideal Gymnopthalmatous Medusa—*a* alimentary—*b* reproductive—and *c* tentacular organs or polyps—*d* visual, and *e* auditory organs.
13. Gemmation of Medusa from alimentary polyp.
14. Do. from reproductive polyp.
15. Do. from tentacular polyp.
16. Eudendrium sessile, with Medusa-buds (eight diameters).
17. Single polyp of do.

On Clava.

1. The genus Clava has been hitherto defined by writers on systematic Zoophytology as a single but gregarious polyp, destitute of a polypidom or corallum. Pallas, who, according to Johnston, first described this animal, writes, "Etiam hæc Tubulariis adnumerari debent Zoophytæ, quamvis ne quidem ramescent ut Coryne, et *tubulo corneo* plane destituta sint." Van Beneden remarks, "The individuals are not united to each

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* Communicated to the Royal Physical Society, Jan. 28, 1857.

other," "at least I have not seen, as in Hydractinia, a common substance which unites all the individuals." Johnston, making no mention of a corallum, says that the polyps are "single," and "fixed by a narrow disc." And the latest writer, Gosse, in his "Manual of Marine Zoology," states that the polyps are naked, and is evidently not aware of the existence of a polypary or common connecting base between them. A similar ignorance of the existence of a polypary and corallum in Clava is also betrayed by Van der Hoeven in his "Handbook of Zoology." If the descriptions given by these writers were correct, Clava would stand alone among all the marine hydroidæ as a naked and single polyp. One species only of this zoophyte has been hitherto described, under the names of *Clava parasitica* (Gmelin), *Hydra multicornis* (Forskal), *Coryne squamata* (Müller), and *Clava multicornis* (Johnston).

2. In a note on Diœcious Reproduction in Zoophytes, contained in the "Edinburgh New Philosophical Journal," vol. iv., p. 313, I mentioned that I had noticed two species of Clava, and that the polyps were not separate, as hitherto described, but were attached together by a fleshy basis, investing a horny polypidom, somewhat similar to that of Hydractinia, or by a creeping thread inclosed in a membranous sheath. In the same month of July, I found a third species at South Queensferry, when examining the shore there with my friend Mr Murray. These three species I propose to designate by the names of *Clava cornea*, *Clava repens*, and *Clava membranacea*.

3. *Clava repens* (Plate II., fig. 1) occurs plentifully on the friable sandstone of the Scougall rocks near Tantallon Castle. Its polyps are joined together by a polypary or cœnosarc, a fleshy fibre inclosed in a thin tubular corallum, which creeps along, and adheres to the stone. This polypary is readily overlooked, as the "colletoderm" or glutinous envelope of its corallum is generally coated with the detritus of the rock and other foreign matters. The polyps have therefore the appearance of being solitary, and ranged in irregular lines, as shown in Van Beneden's drawing.* These polyps are about five or

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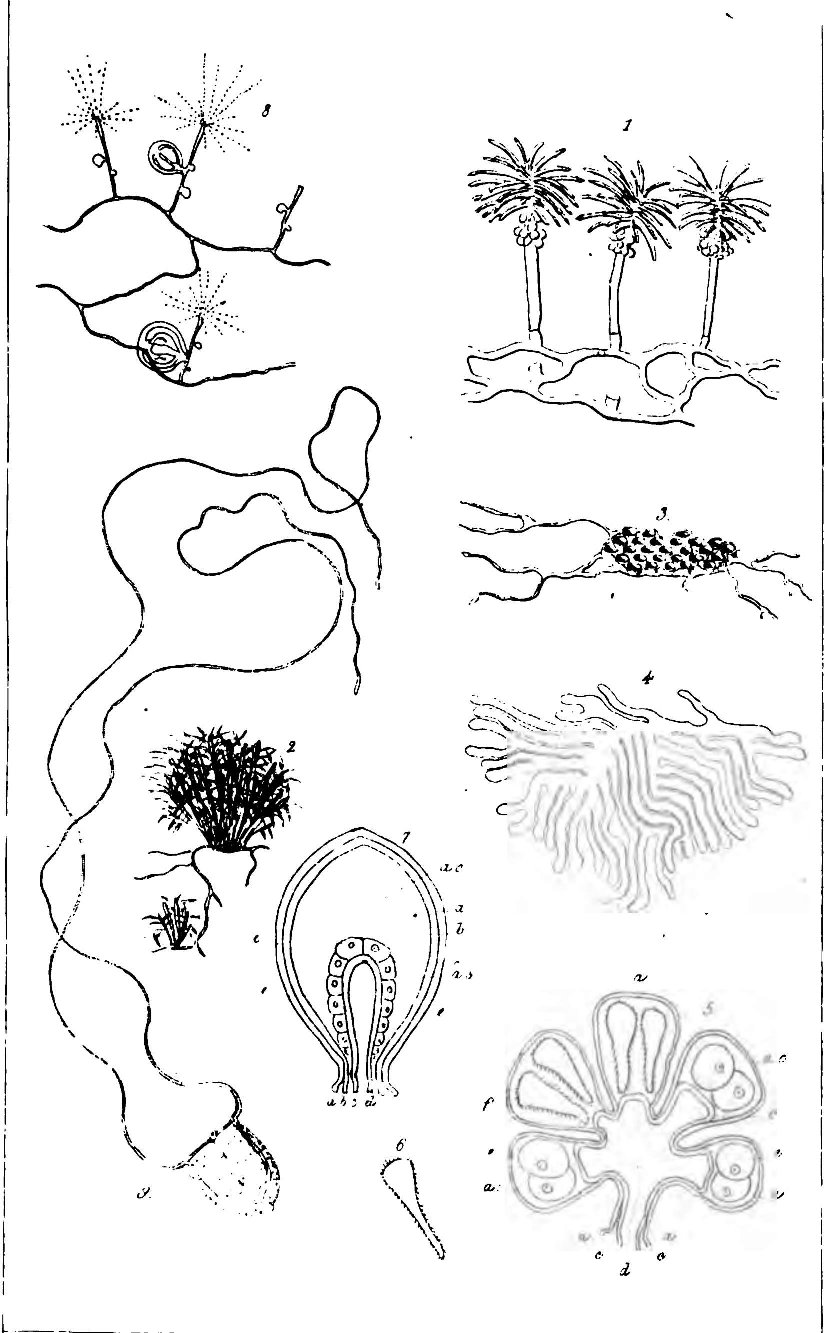
* Recherches sur L' Embryogénie des Tubulaires, 1844.



T. S. [illegible] Wright [illegible] stone [illegible] & W. Fulton [illegible]

Clava 1-7. Eudendrium 8, 9

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six lines in length, white, or coloured with tints of rose or flesh colour, and they sometimes exceed the polypary greatly in thickness. About a half line of their attached extremity is covered by a very delicate extension of the brown corallum, which remains as a cup when the polyp is removed by long maceration in fresh water. The tentacles, from four to about forty in number, according to the age of the polyp, are arranged spirally in several rows round the buccal papillæ. Thick at their insertion, they decrease in diameter towards their extremity, and are extended, with a tendency to droop at the points. Immediately beneath the lower tentacles, the reproductive capsules hang in many-pedicled clusters, so that this graceful zoophyte presents a resemblance to a miniature forest of cocoa-palms heavily laden with fruit.

4. *Clava membranacea* (Figs. 2 and 3).—In this species, found at Queensferry, the polyps are closely massed together in clusters, each cluster being either a male or female zoophyte. The animal was found adherent to fronds of *Fucus vesiculosus*, but so slightly, that the whole cluster could be readily detached by peeling it off with the point of a scalpel. The polyps had a rich aurora tint, and were larger and more slender than those of *Clava repens*, some of them being more than an inch long. The upper surface of the corallum, examined after the removal of the polyps by maceration, presented the appearance of a favoid aggregation of cells, closely cemented together by an excessive development of the "colletoderm." The cement between the cells included several species of diatomaceæ and microscopic algæ. The lower surface of the corallum consisted of a mat of parallel and anastomosing tubes of soft membrane. These tubes also passed beyond the cluster of cells which they supported, and crept along the surface of the fucus in irregular lines, to furnish, as it were, other colonies of polyps.

5. *Clava cornea* is a clustered and diœcious zoophyte, resembling in appearance the species last described. The specimen which I place on the table was kindly lent me, for this evening, by my friend Mr Goodsir, and is one of the results of his trip to the Orkneys with the late Professor Edward Forbes. The polyps are long and slender, like those of *Clava mem-*

branacea. The corallum apparently consists of a thin chitinous plate attached to the fucus. Over part of this plate the chitine rises in low, smooth ridges, running either parallel to each other in winding lines (fig. 4), or meeting at various angles. These ridges have a double contour under the microscope. The polypary lies between the ridges, and consists of fleshy fibres, from which the polyps spring. I believe a thin ring or cup incloses the base of each polyp, and that a membrane also passes from the summit of each ridge to that of the one next it; but I have not been able to satisfy myself on these points. In other parts of the same polypidom the ridges assume the aspect of an intricate net-work, or even a spongy mass, in which the chitinous and fleshy elements are intimately blended together. The whole mass of the polypary, corallum, and polyps, is readily detached from the fucus. [Since writing the above description, I have convinced myself, by the examination of Mr Goodsir's specimen, that the corallum of *Clava cornea* is formed of tubes cemented together, either laterally in sub-parallel lines, or in a more complicated mass. The surface of the corallum of this zoophyte, in fact, has a strong resemblance to the stem of the corallum of *Halecium halecinum*, which consists of a bundle of sub-parallel and anastomosing tubes, more or less closely cemented together, a structure which becomes beautifully apparent in transverse section.]

6. *Reproduction of Clava.*—All the three species of this zoophyte which have come under my observation are unisexual or diœcious; that is to say, the polyps connected by the same polypary have either spermsacs or ovisacs, but not both. The reproductive capsules are amassed together, like bunches of grapes, in one or more thick pedicles, which arise from beneath the lower range of tentacles of the polyp.

In my communication on Hydractinia,* I stated (after Allman and Huxley) that the polyps of all the hydroid zoophytes consisted of three elements:—1*st*, *The ectoderm or outer layer*, the seat of sensation and other external relation, furnished with tactile processes, and with apparatus of offence or defence. 2*d*, *The muscular or middle coat*, specialized for motor function; and, 3*dly*, *The endoderm or inner coat*, of which last, again, the *inner surface* is endowed with the nutritive function, while its *outer surface* subserves to that of reproduction. It is necessary to remember the relation and function of these layers when describing the reproductive apparatus of Clava.

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* Edinburgh New Phil. Journal, New Series, April 1857.

7. The Ovisacs of the female of this zoophyte, of which fig. 5 shows a section of five *in situ*, are found to consist of ectoderm (*a*), muscular coat, and endoderm (*c*), and their nutritive cavity is continuous with that of the pedicle, which, again, is a diverticulum of the alimentary canal of the polyp. In each of the ovisacs at an early period, one, or more generally, two transparent ova appear, consisting of a vitellus and germinal vesicle, inclosed in an envelope, and situated in the generative cavity (*ac*), between the endoderm and the other coats, as in the ovisac of Hydractinia. In the reproductive capsule of *Coryne glandulosa* (Dalyell) the secretion, if I may so call it, of the ova, from the outer surface of the endoderm (as shown in fig. 7), is a fact beyond doubt, but in Hydractinia and Clava their appearance takes place at so early a period of the development of the ovisac, that the seat of their origin can only be inferred from observations in other zoophytes. The ova, after becoming opaque and almost black by the granulation of the yoke, gradually assume a transparent pink tint, and are developed into ciliated planarioid larvæ, which are discharged from the distal extremity of the ovisac, and after gliding over the bottom of the vessel in which they are contained for a few days, become fixed, and changed into minute polyps. In this zoophyte the reproductive process differs from that I have described in Hydractinia, inasmuch as the young arrive at their larval or planarioid stage of development before leaving the ovisac, and the endodermic layer of the ovisac is gradually withdrawn into the pedicle, while in Hydractinia the contents of the ovary are discharged as ova, and the endodermic layer occupies the interior of the ovary to the last, although reduced in volume by absorption.

8. The Spermsacs of the male Clava resemble the reproductive capsules of the female in external appearance and arrangement. The development of spermatozoa in their interior is similar to that I have described as occurring in Hydractinia. We have the same secretion of gelatinous matter from

the external surface of the endoderm; the same development in this matter of minute cells, and the production from these cells of spermatozoa. But while, in Hydractinia, the endoderm of the spermatic capsule is reduced, towards the last stage of the process, to a mere line of brown granular matter occupying the axis of the capsule, in Clava the endoderm is gradually withdrawn from the capsule altogether, and the cavity of the latter at last contains spermatozoa alone. The spermatozoa of Clava, which are very large and active, are discharged from the summit of the spermsac. The ectoderm of both ovaries and spermsacs contains the larger thread-cells in great numbers.

9. The existence of spermatozoa in the reproductive capsules of Clava, a fact unnoticed by Johnston, was discovered by Ratke in 1844, that of ova by Rudolf Wagner in 1836, but neither of these philosophers fully recognised the diœcious character of this animal. Van Beneden also described Clava in 1844, and figured the male capsule, which he mistook for an entire ovum. Van der Hoeven, in his recent work already cited, rather loosely states that the propagation of this zoophyte is effected by buds which contain ova or spermatozoa, and which occasionally detach themselves from the stem on which they are developed, swim freely about, and resemble small medusæ. He gives no authority for such an opinion, and he has probably classed with Clava a number of small clavate polyps with filiform tentacles, such as the *Podocoryne* of Sars, the *Coryne fritillaria* of Steenstrup, and the Zoophyte described at a late meeting of this Society by Mr Peach. There also exist a number of undescribed Tubularian Zoophytes, some exceedingly minute, passing upwards through Clava, Coryne, and Eudendrium, to Tubularia, some of which give off free Medusæ.

Eudendrium.

10. The two new species of this Zoophyte I now describe can lay claim to none of the arborescent beauty which has gained for this genus the name of Eudendrium. So insignificant are they, indeed, that they are easily overlooked, even when carefully sought for. The first species, to which I have given the name of *Eudendrium pusillum,* is found growing on many Ser-

tularians and on the back and legs of the Spider-crab, in which last situation it sometimes occurs in great profusion. It is adherent to these bodies by a creeping tubular corallum inclosing a filiform polypary. From this creeping fibre stems arise at frequent intervals, from about one-eighth to a quarter of an inch in height, and bearing at their summit small white club-shaped polyps. The polyp is capable of partially retreating into the upper part of the tube, which is dilated at this point so as to form an imperfect cell. The filiform tentacles vary in number from four to twelve, according to the age of the polyp, and are held in two rows, the one (generally consisting of four) elevated, the other depressed or horizontal.

At almost all seasons of the year we notice *on the polyp-bearing stems* of this Zoophyte small protuberances, which rapidly increase in size, and become Medusæ or "jelly-fish" of the naked-eyed type.

The Medusa-bud first appears as a diverticulum or sac of the endodermic and ectodermic layers of the polypary, covered by an extension of the corallum. After a short period the diverticular sac becomes depressed at its summit, and at the bottom of the depression a slight elevation may be observed. This depression and elevation are the rudiments of the umbrellas and peduncle of the future medusa or acaleph. The depression rapidly deepens, until the sac becomes folded in upon itself, so as to form a deep bell with the peduncle rising like a thick clapper from the bottom of its concavity. In the mean time the endoderm of the bell (now become very opaque by the deposit of red granular matter within it) has slightly separated from the outer layer of ectoderm, and has become divided into four thick tubular lobes, communicating with each other by a circular canal at their summits, and with the peduncle at their bases, and connected together laterally by the inflected ectoderm, within which a transparent muscular membrane is developed. The ectoderm now forms the umbrella and the endodermic lobes, with their uniting membrane, form the lateral canals, and the sub-umbrella of the Acaleph or Medusa. A constant interchange of circulating particles takes place between the cavity of the parent polypary and the cavities of the peduncle and the endodermic lobes. The process of development goes on, the peduncular sac is changed into a quadrangular polyp, the endodermic lobes into slender canals, bearing at their extremities polyps of a peculiar form, systolic contractions commence in the muscular tissue of the sub-umbrella, and the bud has become a perfect Acaleph, (fig. 9), although still joined by a narrow pedicle to the polypary of the Eudendrium. This pedicle is, however, soon absorbed, the thin covering of the corallum bursts, and the living bubble dashes away through the water, with powerful strokes, a formidable little tyrant of the sea.

When first separated from the Zoophyte, the Acaleph seeks the surface of the water with long zig-zag bounds, carrying its tentacles closely coiled in spirals. Having remained swimming there for a short time, it begins to sink slowly with the mouth of its bell uppermost, and the tentacles, uncoiling themselves, stream behind, to a distance of more than twenty times the length of the bell, in straight lines or graceful curves, sweeping the water in search of prey. In most of the naked-eyed medusæ, the umbrella is so thick and solid, that the shape of the upper part of the bell is but slightly altered by the contractions of the sub-umbrella; but in the species I am now describing the umbrella is thin and soft, so that the whole parietes of the bell contract together at each stroke, forming a curve similar to the wave-line of Scott Russell, and admirably adapted for rapid passage through the water.

A jar of these lively creatures, some swimming rapidly about like small frogs, with their half-coiled tentacles jerking backwards at each stroke, others descending headlong in flocks, like the falling train of a rocket, and all glittering under oblique illumination in the dark water, forms one of not the least interesting of those scenes of beauty which are of daily occurrence to the naturalist.

12. In the Anatomy of the Acaleph of Eudendrium four distinct parts claim our notice.

(1.) The umbrella.
(2.) The sub-umbrella.
(3.) The lateral and circular canals.
(4.) The alimentary polyp or peduncle; and
(5.) The tentacular polyps.

13. In the description of these parts, I shall consider the animal, not as *a sexual polyp,* with Ehrenberg, Allman, Carpenter, and others, but as a free and independent extension of the *polypary* of Eudendrium; not as the product of the alternate generation of Steenstrup, in which the parent is a zoophyte, the child an acaleph, the grandchild a polyp again, and so on in endless succession; but as a new phase in the continued development of the Zoophyte, in which the humble, fixed, and thread-like polypary attains, as it were, a higher life of beauty and motion, and an organization adapted to its changed existence.

14. At our last meeting, I described to the Society that, in the case of Hydractinia (a Zoophyte intermediate in its form and structure between the trne Zoophyte and the Acaleph) we had a polypary consisting of a fleshy expansion permeated by a net-work of tubes, and furnished with organs of reproduction, digestion, and prehension, in the form of reproductive, alimentary, and tentacular polyps. A homologous structure obtains in the Acaleph now under our notice. Instead of a *flat expanded* polypary, we have that body bell-shaped, and represented by the umbrella, the sub-umbrella, and the lateral canals. In the peduncle, we have a single alimentary polyp. While the long tentacles, with their bulbs, form the homologues of the tentacular polyps of Hydractinia.

It is not, perhaps, incorrect to consider, with Allman, the ovaries and spermaries of Cordylophora, or those of Clava or Hydractinia, as sexual polyps; but, as to the naked-eyed Acalephs, produced by gemmation from various hydroid Zoophytes, a knowledge of the anatomy of Hydractinia teaches us that they are something more. They are independent polyparies, having polyps endowed with various functions; some species of them possessing, indeed, differentiated organs of sight and hearing, and being capable, like Hydractinia, of producing other polyparies, similar to themselves, by gemmation.

In fig. 11 I have given an ideal sketch of Hydractinia as a Gymnopthalmatous Medusa, and at fig. 12, having its organs indicated by the same letters, a sketch of an ideal Acaleph or free-swimming polypary, and I have furnished this last with *the alimentary polyp* of Lizzia (*a*), *the reproductive polyps* of

Thaumantias (*b*), *the tentacular polyps* of Sarsia (*c*), with their eye-specks, and the auditory capsules containing otolithes common to the Campanularian and many other Acalephs. Such an animal would be endowed with the power and special apparatus for the exercise of the faculties of motion, sight, hearing, prehension, digestion, and reproduction. It will further have the power of propagating animals similar to itself by gemmation, *from its alimentary polyps*, as in Lizzia (fig. 13), from *its reproductive polyp*, as in Thaumantias (fig. 14), and *from its tentacular polyps*, as in Sarsia (fig. 15); and, lastly, in these budding Acalephs, even while still attached, preparation will have commenced for a still further exercise of the propagative function.

The ovaries or spermaries of Cordylophora and Clava are the germens or anthers of the animal plant, while these Acalephs must be considered as the fruit-bearing branches, leading an independent life. They are the divided parts, paradoxically speaking, of an individual existence.

15. *The umbrella* (of the acaleph of *Eudendrium pusilla*) is homologous with, and developed from, the ectoderm of the polypary. It is a clear, structureless tissue, containing, on its external surface, numerous large thread-cells, each occupying its own sac. It is continuous with the ectodermic layer of the tentacular polyps, and exists as a delicate membrane passing within the bell and partly forming the sub-umbrella, and covering the alimentary polyp.

16. *The lateral canals* (homologous with tubes of the endoderm in the fixed polypary) are situated immediately beneath, and are adherent to, the umbrella. At the summit of the bell they join together to form a quadrangular cavity, and they communicate below with a circular canal, which passes within and around the mouth of the bell. This system of canals is at first lined with red granular matter, which is afterwards absorbed, and it is constantly traversed by streams of nutritive fluid, impelled by ciliary action, and changing the direction of their course at short intervals of time.

17. The *sub-umbrella* is a thin muscular membrane attached to the exterior of the lateral canals on their inner aspect, and along their whole length, and also to the umbrella along four

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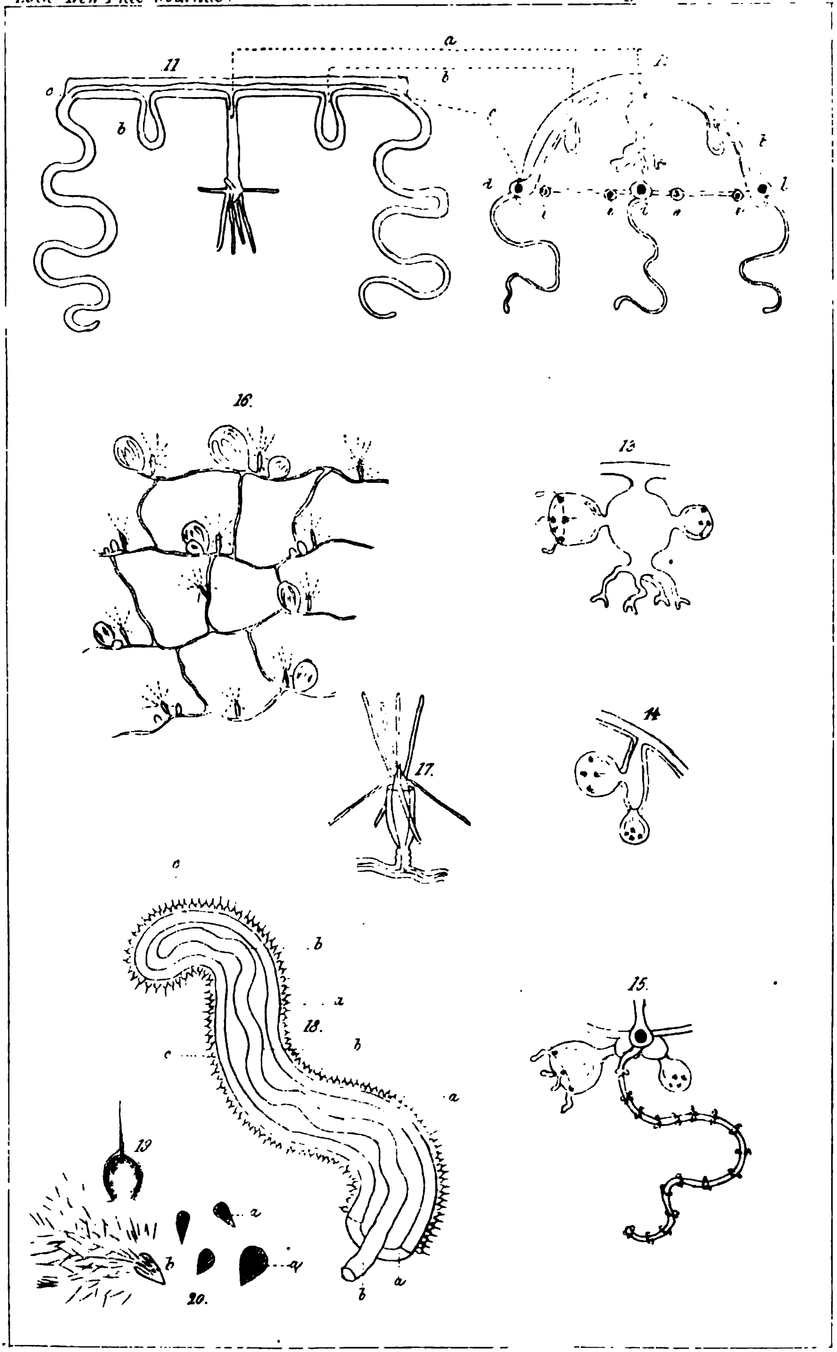

Strethill Wright del. on stone

Schenk & M'Farlane, Lith.rs Edin.r

Eudendrium 11_17. Spio 18_20.

lines running mid-way between the canals. Its function is that of motion; it also acts as an organ of circulation and respiration by enlarging the calibre of the lateral tubes at each of its systolic contractions, and constantly refilling the bell with freshly aerated water. Its structure has a finely dotted or crapy appearance. The dots show a tendency to arrange themselves in transverse lines during the contraction of the membrane, but no true muscular fibres exist. Numerous transparent corpuscles may also be observed scattered with some regularity in the tissue of the sub-umbrella, which, from observations in other classes of zoophytes, I am led to consider as the rudiments of a ganglionic nervous element. Similar bodies, of a fusiform shape, may also be detected along the sides and inner aspect of the lateral canals. The sub-umbrella passes across the mouth of the bell to form the veil, which is perforated in the centre by a wide circular opening. This apparatus, by contracting the jet of fluid ejected from the bell, increases its propulsive force; at the same time, by its projection outwards at each stroke of the sub-umbrella, it renders the *stern*, also, of our little vessel conical, and facilitates its passage through the water.

18. *The alimentary polyp or peduncle* (the digestive organ of the Acaleph) rises from, and communicates with, the confluence of the lateral tubes at the summit of the umbrella. In shape it is short, quadrangular, and without tentacles, differing in this respect from the acalephs of other species of Eudendrium described by Dalyell and Van Beneden. Its structure consists of a layer of highly vacuolated endoderm, covered by a delicate ectodermic investment, containing a fringe of thread-cells round the mouth.

19. *The tentacular polyps* (or prehensile organs) are placed one at each confluence of the circular with the lateral canals. They consist of two parts,—the hollow bulb and the tentacle. In two of these polyps the tentacle is very short, while in the other two, opposite to each other, it is excessively developed, and, when not in use, coiled in a tight spiral. The ectoderm or outer edge of the tentacle, or that which, when coiled, forms the periphery of the spiral, is loaded with small thread-cells, while its inner edge is destitute of those bodies.

No eye-specks or otolithes can be detected in this Acaleph with the microscope, but when a taper is brought close to the side of the vessel in which it is swimming, a brilliant star of light appears at each of the bulbs of the tentacular polyps, reflected from some tissue which I have not been able to detect.

The reproductive organs, which, in the Acalephs of some zoophytes are developed before the separation from the parent polypary, have not appeared during the seven or eight days which the Acalephs of *Eudendrium pusillum* lived in my possession.

Eudendrium Sessile.

19. This species (figs. 16 and 17) is found growing on shells in deep water in the Firth of Forth, and on rocks at the shore about Granton. The red or white polyp is sessile, or united by a very short ringed stem, on a creeping polypary, and it is inclosed up to the tentacles in a membranous tube, which bends with every movement of the body. The filiform tentacles are from two to eight in number, of equal lengths, and carried in two rows, the upper one elevated, the lower one depressed. The Acaleph buds in this species are sessile, and are produced from the creeping polypary, close to each of the polyps, often in pairs. They differ in no respect of either size or form from the Acalephs of *Eudendrium pusillum* already described in this paper.

On the Prehensile Apparatus of Spio seticornis. By THOMAS STRETHILL WRIGHT, M.D., &c.*

Description of Plate III.

Fig. 18. Section of tip of tentacle of Spio seticornis—*a* wall of tentacle—*b* vessel—*c* spine-bearing papillæ.

19. Enlarged sketch of one of the papillæ.

20. Tricho-cysts—*a* entire—*b* ruptured, and discharging spicules.

1. Old shells taken from the sea are frequently found studded with small tubes, composed of mud and sand, cemented together by slime. These tubes are the habitation of the An-

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* Communicated to the Royal Physical Society, Jan. 28, 1857.

nelid *Spio seticornis.* When they are placed in water, we presently see a pair of long glassy tentacles protruded from each opening, which are tossed about with such an incessant and violent motion that we are tempted to believe their concealed owners have taken leave of their senses. If a small piece of oyster is thrown amongst them, it is instantly seized by the waving arms around, and pulled hither and thither, until it is torn to pieces and devoured by the black-eyed and wicked-looking little Annelids, which, forgetting their usual coyness, protrude their heads from the tubes. We observe that the tentacles, when seizing the oyster, attach themselves to it not by winding themselves round it, but by simple adhesion, as if they were studded with numerous suckers and hooks, like the arms of the cuttle-fish. Anxious to examine their microscopic structure, we make many attempts, by rapid clips of our spring scissors, to possess ourselves of a pair of the delicate white arms, but in vain. The Spio, who has all her senses about her, twitches them in, and darts back deep into the substance of the shell, from the mouth of which her tube projects only a little distance. At last we make a successful snip, and a tentacle is placed on the stage of the microscope, still continuing its writhing motions, and gliding through the water as though possessed of independent life.

The tentacle of Spio, the tip of which is shown in fig. 18, is a hollow tube of dense granular parenchyma, covered by a thin layer of transparent tissue. Its interior is occupied by a sinuous vessel, which, in the living animal, is constantly traversed by an ebbing and flowing tide of crimson fluid. The tentacle is thus enabled to discharge the additional function of a branchial organ, and for that purpose is furnished with a ciliated band running from the tip to the base.

The prehensile apparatus of Spio consists of numerous large papillæ, thickly crowded together along the borders of the tentacles. The microscopic structure of these papillæ is exceedingly interesting. They are composed of a prolongation of the granular parenchyma, covered by the transparent layer. At the summit of each papilla, the parenchymic substance is produced through the external layer, as an acuminated soft cilium or spine.

I have already noticed the extensive occurrence of these soft spines, which I have called Palpocils, in the lower classes of animals, as instruments of adhesion or tact. We find them occurring, in an exaggerated state, in some of the protozoa, as in *Actinophrys*, *Podophyra*, and *Acineta;* on the tentacles of *Hydroid* and *Helianthoid Polyps*, accompanied generally, but not invariably, by thread or sting cells. In the polyzoa, situated on the small papillæ, concealed within the jaws of the avicularia, or bird's-head processes of *Cellularia ciliata* and others. In the Mollusca, as in the adhesive tentacular fringes of Lima and others, and on the dorsal papillæ of the Eolidæ. In the Turbellaria; and in the Annelidæ, as in the tentacles of Terebella and others. Probably the long motionless Cilia which grace the tentacles of some of the Rotiferæ, as in Stephanoceros and Floscularia, are of the same nature as these processes.

On forcibly pressing the tentacle of Spio, the spine-bearing papillæ burst, and there issues from each of them a body of a very peculiar kind. This body is a pear-shaped capsule (fig. 20, *a*), which issues from the papilla in which it lies concealed, with its broad end in advance. Under stronger pressure the capsule also bursts, and discharges its contents (*b*), —a multitude of acicular spicules, sharp at each end.

It is impossible to resist the conviction that these sacs are analogous to the thread-cells of the polyp, although their structure differs very considerably from that of the latter organs. They approach more nearly to the tricho-cysts discovered by Allman in *Bursaria leucas*, a protozoan animacule, which consist of fusiform capsules, having a single spicule in their interior, or to the globular thread-cells of Cydippe, described by myself, which contain a simple coiled thread, unaccompanied by the usual invaginated sac which occupies the thread-capsules of the Hydroid Zoophytes.

We cannot, I think, doubt that the tricho-cysts of the subject of this communication are instruments of offence, like the thread-cells of zoophytes. If so, woe to the unlucky inhabitant of "the broad sea wolds" who shall be clasped by the white and blushing arms of Spio, once a powerful Nereid and grand-daughter of Oceanus and Terra, to whom the piety of mankind made offerings of the choicest of milk, oil, and honey, now degraded to the form of a cruel and voracious little worm, and fed by dilettante naturalists on morsels of native oyster. His fate will be like that of the unfortunate whom we have all read of, who, drawn gently into the arms of what seemed a beautiful maiden, suddenly found himself transfixed by a hundred hidden blades projecting through the rich silk that covered her breast.

The Distribution of Rain in the Temperate Latitudes of North America. By LORIN BLODGET, U. S.

The general questions relating to the supply of moisture to the continental areas of the Northern Hemisphere are at present the most difficult in climatology, and, for their solution, an ample collection of facts, from widely distributed sources, is indispensable. The military posts of the United States have recently been extended to nearly every part of the interior and Pacific districts, and the observations required to be made at these posts have supplied some very desirable elements, though the periods of observation are yet very short. An approximation sufficiently near to the true quantities, for many purposes of generalization, may be afforded by four or five years of observation, however, and most of these posts now furnish records for three or five years. Not only the new districts of this continent, but much of the interior of Europe and Asia, assist to furnish this new material, particularly for the belt not yet illustrated, which stretches from the Black Sea northeastward across the Caspian, and over the great areas of Southern Siberia.

To understand the distribution of rain in the United States clearly, it is quite necessary to make some exterior or general comparison of the temperate latitudes, and to do this, if possible, in a systematic manner, or as a whole. The measurements recorded at many new points require such a comparison for the purpose of verification, and without it, it is often difficult to decide on their accuracy. If a comparison discloses symmetrical relations, these may at once decide whether the records are accurate, and whether the collection is sufficient to permit the investigation of exterior questions or those relating to the sources of supply of moisture to land areas. It is still preferable to confine attention to the simple facts of distribution as shown by actual measurements, and to discuss general questions only for the purpose of verifying these.

In this simple distribution there are some noticeable points, both of conformity to the distribution on the eastern continent, as far as we know what that is, and of contrast with it. The most prominent of these, from the European point of view, or, as respects European analogies, is the great quantity of rain falling on the Mississippi plain of the interior; and at distances so great from the coasts, and under such circumstances of atmospheric circulation, as to preclude the idea of direct derivation from the sea. The quantities are not graduated according to the proximity of bodies of water, either at the borders of the Gulf of Mexico or at the Great Lakes. The quantity falling on the area between the 35th and the 40th parallels is immense, and the hypothesis of direct transmission in the surface atmosphere would require a constant and strong sea-wind from the south for most of the year. Without doubt a large quantity of water is so transmitted from the Gulf inland, but the leading relation is that of *capacity for moisture* simply, which capacity may be supplied from a superior current or atmospheric movement as readily as from one at the surface merely. Where the heat is greatest on this plain, and the resulting capacity for sustaining aqueous vapour therefore greatest, there is, on the whole, the heaviest precipitation in the regular recurrence of rains. At Cincinnati the temperature is often equal to that at New Orleans, and the high measure of capacity is fully supplied, producing excessive humidity, and a profusion of rain corresponding to such conditions. This point is 630 miles from the sea, yet it has a mean annual quantity of 48 inches of rain, or more than double that of London or Paris.

At the mouth of the Mississippi both the quantity and the forms of precipitation become, in a great degree, tropical; in the warmer months they are fully so, and it is singular that, from this point northward, the diminished quantity of rain has direct relations to the diminution of heat and the increase of altitude,—this last point again reversing the analogies of the west of Europe. In confirmation of this view, it is found that the upper plateaux or valleys on both sides of the mountain ridges in Virginia receive a quantity much less than that falling in the Ohio valley at the same latitude, differing from that more widely, indeed, than from the quantity on the plains of the Atlantic coast. From Cincinnati the mean of 48 inches is extended nearly to Portsmouth, and it is still 42 inches at Marietta, much nearer the base of the mountains; while at Lewisburg, White Sulphur Springs, Staunton, Winchester, and other places in the various parts of the upper valleys, the quantity cannot exceed 36 inches. All accessible measurements place it lower, indeed, and the general drainage of the region implies only a moderate quantity, with none of the profuse floods so frequent on the Ohio, and on the entire extent of the Atlantic slope.

The western part of the continent differs radically from the condition that has just been described. It is apparent that the different latitudes there reproduce, in succession, the various generic distinctions belonging to Africa, Europe, and Asia in like latitudes. The absence of rain marks a desert belt in both cases; and in each it begins at low latitudes of the coast, to extend over a large share of each continent north-eastward. Sahara, from the 27th to the 32d parallel on the coast of Africa, has a corresponding area at the same latitudes in California; and though there are many local differences between the two, and a much larger development on the eastern continent, the substantial identity of the two cannot fail to be recognised in an illustrative chart.

In all parts of the dry areas this correspondence in leading features, while wide differences of degree, with many local peculiarities, exist, may be traced without difficulty. The transition belt of the Old World occupies a very large space, yet it is here so much compressed as to obscure the points of identity in many cases. The characteristic autumn rains of the north shore of the Mediterranean have been thought to be wanting here, yet they appear very decidedly on the Gulf coast at the mouth of the Rio Grande; and it has been recently shown by the surveying officers who have traversed the west of Texas and New Mexico, that a large area there is characterized by an autumnal rainy season, though the quantity falling is small. It is but little removed from the summer rainy season of Chihuahua and other parts of the north of Mexico, and at the north it merges into the equally distributed rains of the higher latitudes in the extreme north of New Mexico. This is nearly the geographical position the autumn rains of Europe have, and the difference which places these in lower latitudes is due to the greater width of the European belt, since that belongs, in part at least, to the south shore of the Mediterranean.

The next in the order northward is a narrow area having the dry summer of Spain, and moderate winter rains. But for the peculiar cold coast of the summer at San Francisco, this belt of light rains—which fall wholly in winter—would perhaps be wider; but it is now much circumscribed, both in latitude and longitude, bordering closely on deserts inland. The summer rains also extend farther northward in the interior than on the coast, as they are abundant on many parts of the high mountains north, as well as south, of the Gila river, while they are unknown as far south as observations have been made along the peninsula of California.

At the latitude of San Francisco the two divisions of the year become more distinctly defined; and though the quantity for the year is not larger than in France, it falls profusely during the rainy season. The warmer months have none, and this complete interruption belongs to a relatively larger area than on the old continent; the statistics for the belt to which the Mediterranean is central showing a decided contrast with those we have for California. At the 42d parallel the summer rains begin on the Pacific coast in small quantity, and from this point northward they increase rapidly and regularly, so far as known. At Sitka they become profuse and almost constant, and it is probable that they are more abundant above the 50th parallel than in like latitudes of the west of Europe.

For these higher latitudes the Pacific coast has a larger quantity for the whole year than the west of Europe, though the belt of profuse rains is not wide, and in the interior, east of the Rocky Mountains, the quantities are much the same as on the Russian plains north of the Black Sea. The dry transition belt there borders the Black Sea, and extends to the northern extremity of the Caspian, while it ceases here at the plains of the Columbia west of the mountains, and at the northerly bend of the Missouri east of them,—both points nearly at the same latitudes as the dry Caspian basin. The plains of British America are as well supplied with rain as those of the Volga, and apparently better than the high plains or steppes of Siberia. At least they have a supply adequate to the purposes of cultivation, and show no deficiency on the eastern slopes of the Rocky Mountains, at the sources of the Saskatchawan, Athabasca, &c.

This decided abundance on the plains of British America may be taken as strong evidence that the dry plains at the south find their origin in general causes affecting continental distribution, and are not to be attributed to the Rocky Mountains alone. The greater area of the dry belt of the eastern continent is beyond the influence of important mountain ranges, and it clearly is not chargeable to such influences. Though the configuration here may favour the view that all such contrasts are due to configuration simply,—since the mountain ranges near the Pacific are all high, and formidable as atmospheric barriers,—the comparison of the two continents, as a whole, furnishes an analogy so clear that we are not disposed to look farther for the solution of the arid belts. What the ultimate causes of this continental aridity are is not clear; but it is not necessary to enter on that inquiry in order to admit conclusions adverse to those which attribute all these distinctions to the influence of mountain ranges.

In the central area east of the Rocky Mountains there are many interesting anomalies and contrasts which cannot belong to vertical configuration, since the whole is a plain. On the lower Rio Grande there is an autumnal rainy season, which at New Orleans passes into a district having a summer and a winter rainy season, with a small comparative deficiency in both spring and autumn. Here the quantity is nearly twice as great as that at the mouth of the Rio Grande. Further east, April and September exhibit a decided deficiency. This is particularly the case from Pensacola to Charleston, and on the upper part of the Peninsula of Florida. But in Florida the winter is a dry season, and the summer excessively rainy in the southern part. In summer the quantity in Florida is similar to that falling at New Orleans, though perhaps somewhat greater; but in winter there is a quantity three times as great on the lower Mississippi, as in Florida—the quantities being 18 and 6 inches respectively.

Northward in the Mississippi valley or plain the rains for the warmer season increase rapidly in their percentage on the amount for the year,—those for the three months of summer becoming fifty per cent. on the yearly quantity at Fort Snelling. From this last point northward the condition is similar to that on the plains beyond the Volga, though the summer quantity is evidently greater in actual measurement than where it constitutes fifty per cent. of the yearly quantity near the Ural Mountains.

The district of the great lakes is peculiar, repelling the summer profusion as it does, and thus diminishing the yearly sum very much in comparison with the country near it on the south. This influence is most clearly shown at Lake Michigan, around which the quantities for the warmer months increase in all directions. A portion of the high lands in New York, and probably also at the north of Lake Huron and Lake Superior, arrest a larger quantity in summer and autumn, because of the presence of these bodies of water; but this water surface, as well as that of the plains in their vicinity, certainly receives less than the plain of the Mississippi at a distance from them in the same latitudes. Iowa is much more profusely watered than Michigan, and more profusely also than the plain north of Lake Erie, which extends eastward through New York at the south of Lake Ontario.

The valley of the St Lawrence at Montreal and northward is now less known than most other localities. In that part of this valley which lies in New York the quantity of rain is small,—somewhat singularly so near Ogdensburg. But at Montreal it is much larger, according to the two or three years of recent observation, and it appears to be large also at

Quebec. For this area, and its extension northward to Hudson's Bay and Labrador, there is yet too little known to decide whether it has analogies with other districts of similar position on the eastern continent.

It does not appear that any part of the Alleghanies is characterized by the profusion which is directly due to altitude, as on the high lands of the British Islands, and on the various ranges of the Alps. In some parts of New England and New York this increased quantity appears to a certain degree, but never largely; and in Pennsylvania the hills or mountains first begin to produce a diminution, instead of an increase of quantity. In Virginia this is still more decidedly the case,—the whole mountain region being comparatively deficient in the quantity of water falling in rain for every season. Still further south the profuse humidity of the lower Mississippi may add something to the quantity falling on the Cumberland Mountains, and on the southern prolongation of the Alleghanies proper. In Georgia, South Carolina, and North Carolina, the slope approaching the mountains has decidedly less rain on attaining an altitude of 1000 feet, and none of the ridges, or even of the higher ranges, have any marked excess. The *immediate* coast, however, has again a diminution of quantity, the islands and exposed points of the mainland showing less rain-fall, as they show a less excessive saturation, at the extreme intervals; the heavier rains falling at a sufficient distance inland to avoid the cooling sea breezes. This excess at the *inland border of the alluvial plain* characterizes all the southern states on both the Atlantic and the Gulf of Mexico.

The full sea exposures diminish the quantity on the whole coast south and east, at least to the 42d parallel. At Nantucket, and on the eastern end of Long Island, long series of accurate observations afford the same result. At Whitemash Island, near Savannah, Georgia, and at St Augustine, Key West, the same influence is apparent, and great reduction of the adjacent inland measurements appears. The solution of all these facts is undoubtedly the same as in the case previously noticed, where the great lakes are found to reduce the quantity, particularly for the summer, by preventing the high temperature, and consequent excessive local saturation, which prevails at times over land areas.

It is remarkable, that in the United States generally, the sensible moisture should present conditions in marked contrast with the measured precipitation in rain, according to the standard of mutual relations which exists in Europe. At the 38th parallel in the Mississippi valley this is more remarkable than elsewhere, and it is next conspicuous on the Atlantic slope from Massachusetts to Georgia, or most decidedly from Maryland to Georgia. In the lake district the sensible humidity is greater than in the districts just named, while the quantity of water falling in rain is much less. There is something European in the atmosphere of the lake district for parts of the year, though the summer has much of the extreme aridity and elasticity which belong to the climate of the United States as a whole.

There are interesting features of this elasticity and absence of sensible moisture over all parts of the great interior. One of the most noticeable localities is the line which separates the rains and clouds of Upper Texas from the intense aridity of the atmosphere of New Mexico; this line is near the eastern border of the *Llano Estacado* or Staked Plain. The phenomena of violent storms called *northers*, which prevail from Vera Cruz to Galveston, are abruptly changed here, the whole being confined to the area where saturation becomes excessive, and where violent displacements of the local atmosphere attend the precipitation of this moisture in rain.

At the northern border of the summer rains of Mexico, along the mountains near the Gila River on the south, a similarly abrupt transition from a local humidity to an intense aridity occurs; the clouds coming up from the south-east, and wasting suddenly at that limit. At the eastern side of the Sierra Nevada the same transformation of the west winds occurs at the latitude of Los Angelos (35°) in the rainy season, or at its commencement and close.

A local phenomenon of condensation, still more striking as a peculiarity, is found in the fogs of the coast of California from Monterey to Fort Orford. This is intensified at San

Francisco, and it is there clearly seen to be but the simple condensation of the moisture of the heated air of the interior when reduced in temperature by the intrusion of the cold coast wind. This is usually at 57° nearly, while the valleys of the Sacramento and San Joaquin may be at an average of from 85° to 90° for many days, or even months. When this dry wind rises, as the result of the contrasted densities of the air over the cold sea, and of the heated interior, the moisture is condensed by the sudden refrigeration simply, and it often falls or settles slowly in its vesicular form until the surface is wet as from a rain. At sea it does not exist; and it constantly remains along the line separating the sea and interior but a few miles in width. Though rolling its volumes constantly inland, the movement only diminishes the humidity of the interior, instead of adding to it. When the rains commence, the clouds depositing them are high, and with a regular movement from the west. The relations of the local and sensible humidity to the quantity of rain, and to its sources of supply, are similar in some respects over the whole area of the United States to those just described at San Francisco, or they are similarly disconnected and remote.

It may be said of the sources and laws of supply of moisture to this continent, that the entire weight of the leading facts bears against the hypothesis of direct transmission from the sea in the surface atmosphere. With the whole movement of winds, when reduced to a resultant, from west, at the latitudes of 30° to 50° north, we find a *much heavier rain-fall on the eastern half of the continent*, and over areas like the Ohio and Mississippi plain, and the Atlantic plain from Maryland northward. If the Mississippi plain may be supposed to be supplied by the southerly winds of the lower portion from the Gulf of Mexico, it is still difficult to suppose that supply very great at and above Cincinnati, and equally great in Iowa. The relation of the plain of the lakes to those two first named has great force, as proof that a wholly different law of supply exists.

Dove has recently* attributed the quantity of rain for the continental areas more directly to the surface-winds than at any former period, and in support of this view has cited at length the local peculiarities of the transition-belt of the eastern continent. Here this transition-belt is narrower, and its peculiarities are less likely to be taken as the type for other latitudes.

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* "Annalen du Physik." Translated for American Manual of Science, 1855-56.

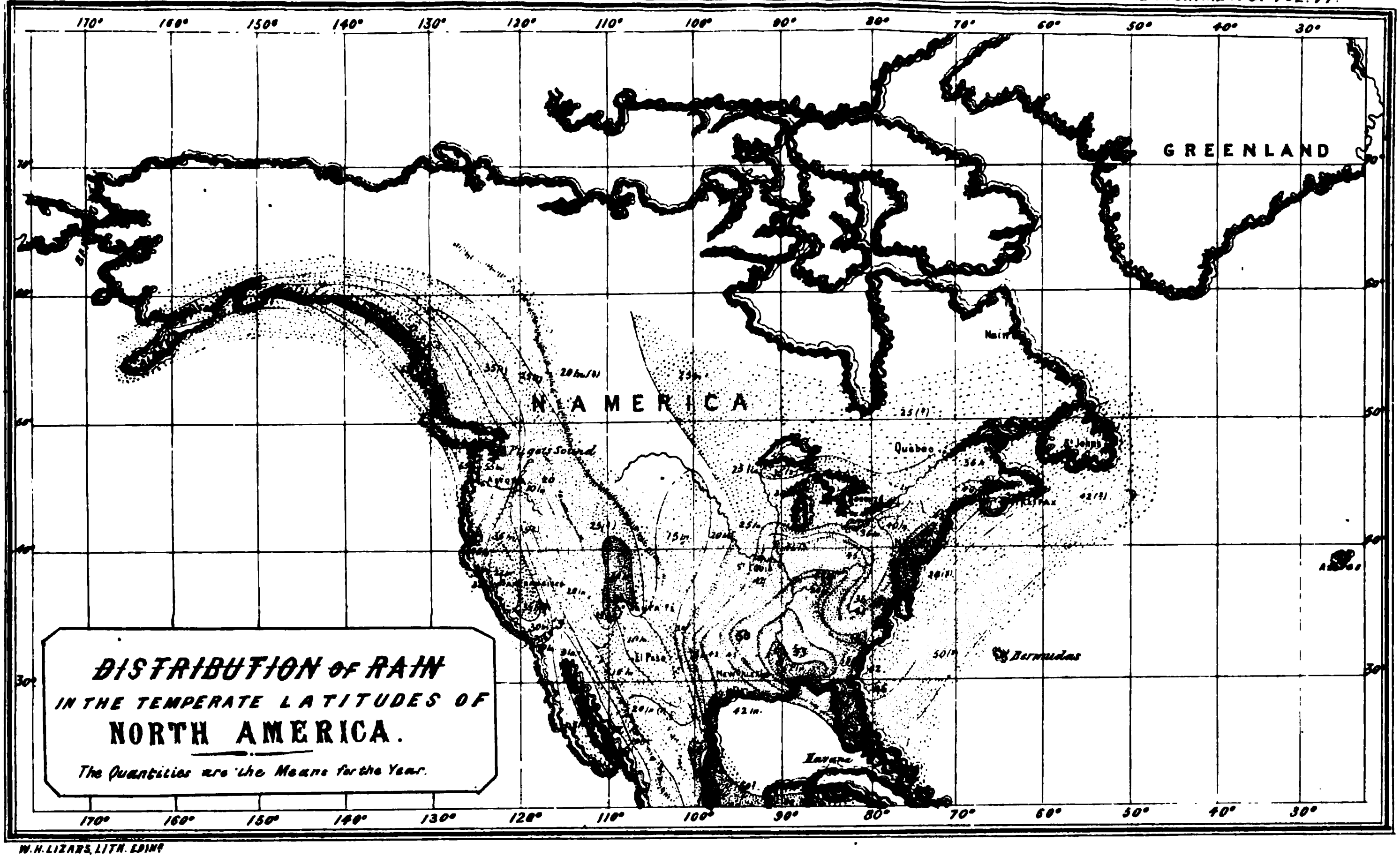
The force of the evidence afforded by the chart in favour of the view taken here as to the sources of supply for the great quantities of rain falling in the eastern United States, depends upon the recognition of the westerly winds as a strong exterior circulation—a circulation not admitted by Dove. But on this point the subject opens too widely for the limits of this paper, and it can only be said that the evidences of this exterior circulation furnished by American observation appear overwhelming.

The accompanying chart (Pl. IV.) shows some of the more prominent features of the distribution of rain in North America, though larger areas of observation are wanting. The greatest want is at sea, however, and it is impossible to say what the graduation seaward is anywhere except on the Atlantic coast. There it is unknown beyond a few miles; and whether the Gulf stream has a belt of excess can only be inferred from the general path it appears to furnish for the greater storms.

On the scale of the map, the areas of small quantity appear large, and if the extreme latitudes were included, the proportions would be yet greater. The belt of excessive rains at the north-west is also large, and what the shading seaward should be cannot now be defined. The belt of excess is narrow, though it occupies a long line of coast. The number of 80 inches at Sitka is somewhat less than the actual measurement, and the other quantities are derived from this point alone for all the coast above Puget's Sound.

The quantity on the mountains near the Pacific is of course but a rude approximation, since measurements are impossible, and there is little local uniformity. Portions of the Sierra Nevada have more than 35 inches, and other portions clearly much less. The coast-ranges are also very variable for localities varying little in position or altitude. The mountains of New Mexico are equally variable, and sometimes a great pro-

PLATE IV.



DISTRIBUTION OF RAIN IN THE TEMPERATE LATITUDES OF NORTH AMERICA.

The Quantities are the Means for the Year.

W. H. LIZARS, LITH. EDINR

fusion occurs in close proximity to localities having very little, or none. Whether this variability belongs to the ranges southward in the interior of Mexico is not known; but there is some reason to believe that they are more uniformly watered when rains fall, since the temperature is much less variable, and the change of seasons affects them less.

Some minor distinctions, which are elsewhere given on charts of a larger scale, do not appear on this, though this may suffice to give some general view of the distribution of quantities.

On the Composition of the Phosphate of Lime existing in Sea-Water. By AUG. A. HAYES, M.D., Assayer to State of Massachusetts, U.S.A.

The presence of phosphate of lime, as one of the constituents of sea-water, was long since pointed out, and from time to time its proportion, relatively to other substances forming deposits from the water by evaporation, has been the subject of special researches.

In the past state of our knowledge it had been supposed that the phosphate of lime found in the analysis had the composition of $3\,CaO\,PO^5$, or bone phosphate, dissolved in virtue of the solvent power of saline water.

Some experimental results, which I have lately obtained, have led me to doubt the accuracy of our knowledge on this subject, and may be of interest to chemists and geologists, as this almost universally distributed salt seems to have had an influence in the formation of secondary rocks, as a cement and otherwise.

When bones, with adhering muscles and tissues, are immersed in water, either pure or saline, in a temperature of 60° or 80° Fahrenheit, a fermentative decomposition takes place, and continues for some time. The fat cells of the tissues become broken, fatty acids and oils are separated, while a superficial breaking up of the structures of the bone occurs. Translucent bones and fish bones are rendered opaque; and the appearance of amorphous products indicates that an important change of chemical composition goes on in their masses. The water becomes covered with a film, and deposits adhere to the sides and bottom of the containing vessel, while suspended matter gives a grayish hue to the fluid. Several of the acids formed in the decomposition of organic matter, in presence of azotized compounds, such as the lactic, crenic, and more rarely the acetic, are recognised early; in the later stages, the butyric appears. The mere solution of the juices of flesh are slightly acid in their secretion; but the most remarkable condition which follows the first stage in the decomposition of the bone, is that of the *alkaline* reaction of the fluid. It can be demonstrated that *no ammonia has been formed;* and a number of observations indicate that a solution of a small quantity of carbonate of lime in carbonic acid and water is not the cause of alkaline reaction.

By heat cautiously applied, the albuminous matter of the solution may be coagulated without destroying the alkaline action of the fluid, and the separation of suspended substances being effected, a clear alkaline fluid may be obtained, in which the acids appear to be united to protein compounds, derived from the tissues.

On adding to the clear fluid some solution of ammonia, a precipitate of phosphate of lime and phosphate of ammonia and magnesia, mixed with some organic salts of lime, falls. There is nothing here presented, unlike the ordinary solution of bone phosphate of lime in gelatinous solutions by heat, and, without further examination, the case might be passed as one presenting only the usual results. By boiling the fluid a few moments, and allowing it to cool,—an excess of ammonia being present,—the phosphates and other compounds of earths and oxide of iron may be removed, and the filtered liquid obtained clear and nearly colourless. On adding to the clear filtrate a solution of wine and ammonia and water, *an abundant precipitation of bone phosphate of lime occurs;* an excess of the lime solution being present, the whole of the phosphate of lime falls, and may be washed on a filter, as usual. Without insisting on the accuracy of this mode of separating the phosphate of lime, still it offers great facility of application, in studying the progress of the decomposition of the bone, and solution in water of phosphate of lime; enabling us to prove, that in the presence of decomposing animal matter, some bone phosphate of lime, or $3\,CaO\,PO^5$, is only slightly soluble in water.

As the second precipitation of phosphate of lime caused by the lime solution proves the existence in the liquor of an excess of phosphoric acid, the character of *alkalinity* noticed in the liquor from bones becomes the more remarkable; and in further elucidation of this point, it was found that phosphorus, oxidizing in contact with animal tissues, would produce its oxygen acids in union with protein compounds possessed of marked alkalinity.

Adopting the more accurate processes for determining the proportion of phosphoric acid, it has been demonstrated that the decomposition of bone may give to the fluid in which it is immersed a phosphate of lime no more basic than $CaO\,PO^5$, and even more acid solutions have been formed by a continued action.

The known composition of bone requires, for the production of the monobasic phosphate of lime, the withdrawal of not only the two equivalents of lime, but also the carbonate of lime, forming about ten per cent. of the mineral matter, by *acids engendered from the animal substances decomposing with it.* The deposition taking place in the fluid consists of crenate, stearate, oleate, and carbonate of lime: there are present, also, some undetermined salts, or compounds of lime and animal matter; and no one can pursue these inquiries into the products of decomposition without having the suggestion arise, that the chemical constitution of bone may be very different from that which our analyses show. Early in the progress of decomposition we notice the solution of the bibasic phosphate and the appearance of a protein compound of lime, the separation, as it were, of two constituents of bone by a proximate analysis. Later, the presence of salts formed by acids renders the problem more complex, though not less interesting in character.

In the description of the decomposition of bone and tissues in water pure or saline, here briefly given, I have confined the expression to the case of complete immersion. When bone, with the adhering tissues and muscle, is exposed so that part is immersed in water and part remains in the atmosphere, the decomposition proceeds with other phenomena. The acids of animal decomposition, with their attendant ethers, appear, and the solution is always acid; while the separation of the lime from the basic phosphate takes place through the affinity of the acids with which it combines. It is well known that recently formed phosphate of lime is decomposed in part by carbonic acid in solution, or by a current of the acid gas; and this acid is one resulting from the changes which the crenic acid suffers when exposed to air. In this double exposure there is therefore less of novelty attending the changes, although the results are equally important; for the tribasic phosphate may thus become converted into the monobasic phosphate of lime, in presence of, and in contact with, recently precipitated carbonate of lime. We may even displace phosphoric acid from bone-ash by sulphuric acid, in presence of protein compounds, and an excess of carbonate of lime, without combining the phosphoric acid of the bibasic phosphate with the lime of the carbonate. On varying the circumstances, so that after a double exposure the decomposing matter may be immersed wholly in the fluid, *the acid state disappears*, and is succeeded, after the lapse of some time, by the alkaline state described above. Where bone decomposes naturally, this double exposure is doubtless that most commonly observed; but the changes taking place in dead organisms immersed in the ocean belong to the conditions productive of alkalinity, and lead to the conclusion that, under these conditions, either the monobasic or bibasic phosphate exists in sea-water. In this view, the phosphate of lime in sea-water cannot be the tribasic or bone phosphate, because its most obvious and abundant source is found in the presence of decomposing organisms, constantly undergoing the earlier as well as final changes.

If the bones of organisms in their natural transformations give rise to mono and bibasic compounds of phosphoric acid and lime, which, either natural or alkaline, from the presence of organic matter, dissolve in sea-water, then it follows that one or both of these salts may be that best adapted to the formation of new bony structures of the animals assimilating them. It is not necessary here to name the many secretions and fluids of the animal system, known to every chemist, in which the phosphoric acid present is in too large a proportion to form bone phosphate with the lime also engaged, nor to refer to the composition of the phosphate of lime found in the stomach during healthy digestion, for evidence in support of the conclusion I have presented. Indeed, it appears probable that we have often overlooked this bibasic composition of the phosphate of lime, solely in consequence of its apparent incompatibility with alkaline reaction in the fluids under examination.

Although the subject, as here presented, was one of special research, yet it is connected with one of a more general character, in which, under a new aspect, we have a striking illustration of bone decomposition, as afforded by its final results.

On the Composition of the so-called Guanos of the Atlantic Islands. By Aug. A. Hayes, M.D., Assayer to State of Massachusetts, U.S.A.

The deposits formed on islands frequented by sea-fowl, and exposed to tropical rains and winds, have within the last few years become an article of commerce in the United States, chiefly as a source of phosphate of lime. Unfrequented islands have consequently been stripped of their coverings, and large quantities of various compounds, containing phosphoric acid, have become well known to those chemists who have engaged in the analysis of them.

These guanos have generally been supposed to differ from the Peruvian guano, in the particular, that the ammonia salts have been washed out of them, leaving the earthy salts behind; but no evidence has been adduced proving that ammonia compounds have been formed during decomposition.

In the following description, it is my intention to include under two heads all the varieties that have been abundantly found:—

1*st*, *Arenaceous Guano.*—This variety, where it has been freely exposed, is generally white, with some shade of yellowish-brown. It is a somewhat coarse sand, resembling coral sand, and we find in it remains of bones of fish, those of other marine animals, and the shells of shell-fish, reduced to a coarse powder.

The deposit on the Aves Island is thus characterized, while that from the Cuba Keys, and other points, is more finely divided, and still contains humus of flesh. These seldom afford more than sixty parts of bone phosphate, from one hundred pints of the dry sand; the remainder being nearly all carbonate of lime. Where the food of the fowls has been almost exclusively fish, and the droppings have been protected, we find a larger percentage of bone phosphate of lime.

2d, Rock Guano.—The mineral I have named rock guano is in the form generally of an irregular incrustation, from one inch to two feet in thickness, pale yellowish-brown, or nearly white in colour, its fracture showing a deeper shade in bands, alternating with those of a lighter colour. Like compact calcareous concretions, the exposed surface presents rounded elevations, while within, the mass is full of cavities and air-passages. Its fracture, generally splintery, sometimes assumes a conchoidal form, and its hardness, greater than that of fluor-spar, is next to that of feldspar; average sp. gr. 2·440.

Varieties are numerous, referable generally to a kind of secondary action, in which the matter of comminuted bones has mixed with beds of recent shells, and not only consolidating them, but decomposing the carbonate of lime in their structures, has converted it into phosphate of lime.

By far the most remarkable form of rock guano is of recent discovery. It is a rock much resembling some trachytes, having natural cleavage planes, which divide it into rhomboidal masses of various sizes. The recent fracture discloses grains disseminated, which, partly resembling feldspar, might be mistaken for this mineral; with light and dark-coloured sandy grains, coloured by iron oxides, cemented as it were by a yellowish-green mineral, might at once be pronounced to be epidote.

I have been informed that the island from which this rock was brought has been surveyed, and was supposed to be of *volcanic origin*, in consequence of its basis rock being pronounced recent trachyte, while it is truly consolidated bones, of altered composition, the lime base replaced by iron and in part by oxide of manganese.

In stating the composition of rock guano, as no two specimens are alike, I purposely omit several constituents which occur in minute quantity, and keep in view the phosphate of lime and organic matter as the prominent constituents. The composition of the arenaceous guano—found on the same spot below the rock guano—on Monk's Island, is also given for comparison.

100 *Parts of Rock Guano.*		100 *Parts of Arenaceous Guano.*	
Moisture,	0·80	Moisture,	6·84
Dry organic acids, humus, &c.	11·00	Dry organic acids, humus, &c.	1·80
Sulphate of lime,	7·90	Sulphate of lime,	7·00
Bone phos. lime & magnesia,	110·20	Bone phos. lime & magnesia,	114·40
Sand,	0·80	Sand,	0·60
	130·70		130·64

The bone phosphate here stated is the proportion obtained by adding sufficient lime to combine with the phosphoric acid present. My own analysis of the vertebra of the halibut gave 86·8 parts of bone phosphate of lime in one hundred parts of the gently-calcined ash, while so much of the fresh bone and tissues as afforded 100 of ash, after treatment with carbonate of ammonia, decomposed by acids, gave 92 parts. The food of fowls we know to consist of shell-fish in part, and consequently the bone phosphate originally present could not have contained so much as 86 parts of phosphate of lime; while the really existing phosphate in the rock guano produces more than 125 parts. This composition offers the clue to the explanation of the secondary origin of the guano as a rock presenting varied physical characters, and leads us to inquire into the chemical influences exerted, while the excrement of birds mixed with more or less of other animal remains, undergoes decomposition at temperature not below 85° Fahrenheit; both water and moisture, being present as aids.

Experiments show that, under these conditions, putrefaction proceeds with the production of acids. The first effect observed on the recent droppings is the removal of the urates, and other soluble excretions which are ammonia producers, by rains. Then the crenic, humic, carbonic, stearic, and oleic acids begin to combine with lime as they form or are separated from the animal matter; and these lime salts being in turn carried off by rains, the phosphate of lime of the divided bones becomes less and less basic in composition. Halibut bones, even after they have been long boiled in pure water, to remove animal tissues, give to sea-water lime salts abundantly as they decompose, and the quantity of fatty acid salts formed is very large. The salts of fatty acids are among the most permanent products of decomposition, and we find them in the composition of most of the remaining forms of the organic matter. The breaking-up of bone, in a limited quantity of water, proceeds until the presence of mono and bibasic phosphate, crenates, stearates, &c., establish a balance; but where rains are frequent, this limit is not reached, as the removal of the lime salts allows the *phosphoric acid* to be actually disengaged, and to act on carbonate of lime. Thousands of tons of both arenaceous and rock guano have been imported in which the phosphate of lime of the mass was bibasic; while the varieties which are formed by the conversion of beds of shells into phosphate of lime show that a higher state—even that of acid reaction—must have been attained in the mass.

In the composition of the rock guano, we see that the proportion of organic acids and salts is much larger than exists in the arenaceous guano from which it has been derived. The presence, to a greater or less amount, of this matter alters the physical characters of rock guano; and it often is almost entirely abstracted, apparently subsequently to consolidation. When the organic matter passes to the state of carbonic acid, the removal of the excess of lime by the ready solubility of the bicarbonate of lime formed may proceed rapidly, and we always observe in the older rock, thus deprived of organic matter, innumerable channels through which the solution has passed apparently.

The cementation of the sandy grains into rock is one of the most interesting features of this subject, as it throws light upon many similar operations constantly progressing. In point of size, the grains of the sandy guano vary from that of fragments of bone and vertebra to minutely-divided processes, in which infusoria shells abound mixed with the seeds of grasses. The first stage of the change into rock is the aggregation of these grains to form a kind of sandstone, in which the individual particles are seen, and this aggregation may take place in the beds. In the guano rock this individuality is entirely lost to the eye, which detects nothing in the close-grained and compact banded mass, to indicate its origin. Mineralogically these bodies are diverse, and some specimens, containing converted shells, are puzzling problems to be solved with the knowledge already obtained.

Rock guano, wherever it has been observed, with one exception, occupies the highest part of the island surface, or covers the arenaceous form; we cannot, therefore, explain its aggregation by the usual effect of infiltration of earthy salts dissolved, but must give great weight to local phenomena of evaporation. The small islands on which it is found are swept by the constant currents of the trade-wind, and the evaporation of water from their surfaces exceeds in amount that received as rains; it being well known that none but saline water is found in the soil. When water holding saline matter in solution evaporates from the surface of the earth, pure water arises in vapour, while saline compounds remain at or near the surface. In accordance with this law, the solution formed by rains permeating a bed of decomposing bone remains of bird droppings, rises to the surface of the bed, and then becomes concentrated. Any acid ingredient would act on the grains it wets, while suspended matters would fill the interstices; and so long as capillarity existed, finely-divided and saline parts would thus increase at or near the surface, and be deposited in the porous portions, gradually filling the pores, and consolidating into mass the granular remains. Doubtless while one part of this process was proceeding, rains carried down a part, which subsequently was raised anew, until finally the surface rock, no longer pervious to rain, became cemented into the compact state it now presents by the conjoined forces acting. The exceptional case referred to, when remarking on the relative positions of the compact and sandy guanos, is that of the new discovery of the trachyte-like form of guano rock.

So far as can be judged from the chemical composition of this rock, which is hydrous, and its mineralogical characters and positions, it was originally formed in the way described above, when its place was the upper surface of the island. But its iron and manganese constituents, the existence of crystalline phosphates, as well as the silicate of alumina and iron, in the form of clay from volcanic rocks, lead to the opinion that it has been long submerged below the waters of the ocean, and there gained its close resemblance in its larger features to trachytes and basalts.

As the materials of the minerals here described have been at one time organized, and may now be considered strictly mineralized, the specimens present fine illustrations of the important action of minor chemical forces in changing the physical conditions of matter, by which the bones, once the food of fowls, have become converted into rock. On the other hand, we find, in the products of the decomposition of bones added to sea-water, the phosphoric and organic salts of lime essential to the continuance and multiplication of animal life there in its various exhibitions.

On the Chemical Composition of some Norwegian Minerals.

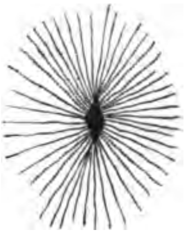
By David Forbes, F.G.S., A.I.C.E., F.C.S. Part III.

VI.—*Orthite.*

This mineral is of very frequent occurrence in the granite veins which traverse the metamorphic schists of the south-west coast of Norway.

It is so constantly present in one variety of granite, that its appearance may be regarded as characteristic of this rock, which, when Orthite is associated with it, appears to be a compound consisting of quartz, mica, and two feldspars, apparently orthoklase, with a much smaller proportion of oligoklase. As far as my investigations have extended, Orthite does not appear to occur in the other varieties of granite.

The crystals of orthite are almost invariably surrounded by a peculiar radial development of fine lines running into the matrix, whether this be quartz or feldspar.



The annexed woodcut shows this appearance, which is as peculiar as it is difficult of explanation.

The lines themselves are true cracks, and appear to increase in length and general development with the size of the crystal from which they radiate; so that in some of the largest crystals of orthite, which occasionally are found so large as to weigh several pounds, these cracks may extend as far as several feet from the crystal. They are rarely if ever altogether absent, even when the crystals of orthite are very minute.*

The orthite here analysed is from a granite vein at the Naes Grube, about ten English miles east of Arendal, and was surrounded by dark-red orthoklase.

It was but very indistinctly crystallized, and had only traces of cleavage planes. The fracture was subconchoidal, and hardness = 6.

Colour greenish-black; streak greenish-gray; opaque, with a faint resinous lustre.

The specific gravity of two pieces taken at 60° Fahrenheit, was found to be respectively 2·86 and 2·93.

Before the blow-pipe on charcoal it swells, becomes brownish-yellow, and fuses to a black glass; with borax in the oxidating flame it dissolves to a reddish-yellow glass, which, on cooling, assumes a faint yellow colour. In the reducing flame the glass shows the same colour, but with a faint greenish tinge.

With phosphate of soda and ammonia it leaves a skeleton of silica, and in the reducing flame affords a glass, which when warm is green, but colourless on cooling. In the oxidating flame the glass is brownish-yellow when warm, and colourless when cold; affords indications of manganese when treated with soda; heated in a tube it swells up, evolves water, and becomes lighter in colour. It is completely decomposed by hydrochloric acid, and gelatinizes; the solution affords traces of metals precipitable by sulphuretted hydrogen.

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* I have noticed that this radial development occurs also with some other minerals associated in this granite, as Gadolinite, Malakon, Tachyaphaltite, Alvite, Tyrite, Ytterspath, Oerstedite. Also in the following minerals peculiar to the Zircon syenite of Brevig, as Thorite, Tritomite, Orangite, and a zircon-like mineral not yet analysed. It, however, appears to be most particularly characteristic of Orthite.

A preliminary analysis of this orthite was published by me in a paper in the Norse Magazin for Naturvidenskaberne,* some years back—the results tabulated as follows:

Silica,	31·03
Alumina,	9·29
Glucina,	3·71
Sesquioxide of iron,	22·98
„ of cerium,	7·24
Protoxide of lanthanum with didymium,	4·35
Yttria,	1·02
Lime,	6·39
Water,	12·24
Alkali and loss,	1·75
	100·00

The alkalies, magnesia, and oxides of copper and manganese present were not determined.

Very shortly afterwards an analysis of precisely the same orthite† was published by H. Strecker, with the following results.‡

Silica,	31·85
Alumina,	10·28
Protoxide of iron,	19·27
„ of cerium,	12·76
Lime,	9·12
Magnesia,	1·86
Oxide of copper,	0·54
Water and carbonic acid,	13·37
	99·05

In my analysis the cerium and iron existing in the orthite are tabulated as sesquioxides, whereas in the other they are calculated as protoxides. It is most probable that both protoxides and sesquioxides are present; and the fact that chlorine is not evolved when the orthite is dissolved in hydrochloric acid, is not sufficient to decide that the cerium present is in the state of protoxide; for if the iron in the mineral existed as protoxide, as the greater part assuredly is, the chlorine eliminated by the action of the hydrochloric acid on the sesquioxide of cerium would not be evolved, but at once be converted into hydrochloric acid, with peroxidation of the protoxide of iron.

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* Mineralogiske Iagttagelser omkring Arendal og Krageræ af D. Forbes og T. Dahll, in Nyt Magazin for Naturvidenskaberne, vol. viii. part 3. 1854.

† Taken simultaneously at Naes Grube from same mass of orthite.

‡ Christiania Universitets Programme for 1854.

Rammelsberg has shown that in the orthite of Hitteroe the oxide of iron present is a compound of the protoxide and sesquioxide in nearly equal amounts. He, in conjunction with nearly all the chemists, look upon the cerium as present as protoxide, which, if accepted, must cause the foregoing analysis to be corrected as to amount of oxygen.

Since the publication of the above analysis, I have again examined this orthite, and am now enabled to bring forward results which I believe to be still more accurate; but it was not considered that the present methods for separating compounds likely to contain protoxides and sesquioxides, both of cerium and iron, were sufficiently correct to enable the respective state of oxidation of these oxides to be determined with accuracy, and therefore they are noted in the results as protoxides, although there is much reason to suppose that some sesquioxide is present.

The analysis was conducted as follows:—A weighed amount was decomposed by hydrochloric acid, and, after adding a little nitric acid, the whole was evaporated to dryness, and then redissolved in water containing some hydrochloric acid. The silica thus left insoluble was collected and determined. Its purity was ascertained by solution in hydrofluoric acid and evaporation.

The solution was now neutralized by ammonia, and precipitated by oxalic acid, so that it reacted, now slightly acid. This precipitate was filtered off after standing twenty-four hours, and collected; then ignited and dissolved in hydrochloric acid, precipitated by ammonia and filtered. The filtrate now contained the lime which was precipitated as oxalate, and determined as carbonate, after ignition, with the usual precautions.

The precipitate by ammonia now contained the cerium, yttria, and oxides of lanthanum and didymium. The yttria was separated from the other oxides by dissolving them in a little dilute sulphuric acid, and treating the solution by a concentrated solution of sulphate of potash; it was then precipitated from the filtrate of potash, washed well, redissolved in hydrochloric acid, reprecipitated by ammonia, and determined. The cerium compound precipitate was dissolved in water, acidulated with hydrochloric acid, and precipitated by ammonia, well washed, ignited, moistened with some nitric acid, again ignited, and then boiled in a solution of chloride of ammonium, which dissolved the protoxide of lanthanum, and probably some didymium, leaving the sesquioxide of cerium insoluble, and, from its brown colour, evidently containing didymium. These were both determined as usual, the oxide of lanthanum being precipitated by ammonia.

The original solution from which the oxalates had been separated was now precipitated by hydrosulphide of ammonium, and collected, then redissolved in nitro-hydrochloric acid, and precipitated by ammonia. This precipitate, which now contained sesquioxide of iron, alumina, and glucina, was treated whilst moist with a solution of carbonate of ammonia, which dissolves the glucina, which was then separated by filtration, and determined.

The alumina was then separated by boiling in potash, and both it and the iron determined as usual.

Another portion of the mineral was employed to determine the amount of oxide of copper present. It was dissolved in hydrochloric acid, filtered, and sulphuretted hydrogen passed through it; only a minute amount of sulphuret of copper was found, which was neglected; and it appeared that the presence of copper was due to some particles of copper pyrites mechanically entangled in the orthite, so that in the specimen here analysed, which was carefully selected, then broken up and carefully picked, only a trace was found.

A third portion of the orthite was reserved for determining the alkalies and magnesia, also to verify the lime determination.

This was decomposed by hydrochloric acid, some nitric acid added, evaporated to dryness, redissolved in water, acidulated with hydrochloric acid, and precipitated by ammonia in excess, filtered, washed, and the filtrate* precipitated by oxalate of ammonia, and the lime determined as carbonate, after ignition with some carbonate of ammonia: it was found to contain a little oxide of manganese, which was separated by dilute acetic acid, and estimated, its weight being subsequently deducted from that of the carbonate of lime.

The solution, after separating the lime, was evaporated to dryness in a platinum capsule, and ignited, to drive off all ammoniacal salts, after which the residual alkaline and magnesian chlorides were weighed, and then redissolved in water, and the magnesia separated by caustic barytes: the filtrate was acidified by sulphuric acid, and the resulting sulphate of baryta separated by filtration: the alkalies were then estimated as sulphates, after evaporation to dryness, and heating.

The relative amounts of potash and soda were estimated indirectly by determining the amount of sulphuric acid contained in the mixed sulphates, and calculating therefrom. By subsequently calculating the amount of chlorides equivalent to the potash and soda thus found, and deducting this from the total weight of the mixed chlorides the amount of chloride of magnesium was obtained from which the magnesia was calculated.

The water contained in the mineral was determined from the loss sustained in heating a known weight of the purest orthite for some time. No carbonic acid was detected when perfectly unweathered fragments of orthite were examined.

The obtained amounts were as follows: 23·46 gr. afforded—water 2·87 gr., 7·28 gr. silica, 0·87 gr. glucina, 5·39 gr. sesquioxide of iron, 2·18 gr. alumina, 1·69 gr. of sesquioxide of cerium, 2·68 gr. carbonate of lime, 0·24 gr. yttria, 1·34 gr. oxide of lanthanum. 50·35 gr. afforded 6·02 gr. carbonate of lime, containing 0·04 gr. oxide of manganese, also 3·71 gr. alkaline and magnesian chlorides, from which 1·49 gr. alkaline sulphates were obtained, which subsequently produced 2·54 gr. sulphate of baryta.

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* The filtrate, after having been acidified by hydrochloric acid, was now tested by sulphuretted hydrogen for copper, but only gave a very faint trace; it was, therefore, again neutralized by ammonia.

From these data the following percentage composition was deduced.

		Oxygen.		
Silica,	31·03	16·42		
Alumina,	9·29	4·51	6·85	16·28
Glucina,	3·71	2·34		
Protoxide of iron,	20·68	4·59	9·43	
" manganese,	0·07	0·01		
" cerium,	6·74	0·97		
" lanthanum,	4·35	0·63		
" copper,	trace.	—		
Yttria,	1·02	0·22		
Lime,	6·68	1·90		
Magnesia,	2·06	0·82		
Potash,	0·90	0·15		
Soda,	0·56	0·14		
Water,	12·24	10·88		
	99·33			

It is worthy of remark, that this orthite which contains so large an amount of water does not present any appearances which would have been produced had the water been subsequently introduced by infiltration; it is hard, and possesses a clear and brilliant fracture, and shows no signs of alteration from weathering or otherwise; it must therefore be supposed that the water here present is due to the chemical constitution of the mineral, and not that it is an allanite (or anhydrous orthite) altered subsequently. The formula deduced from the above analysis is

$$3\ \mathrm{RO\,Si\,O_3} + 2\ \mathrm{R_2O_3\,Si\,O_3} + 10\ \mathrm{HO}.$$

or otherwise expressed,

$$(\tfrac{3}{5}\,\dot{\mathrm{R}} + \tfrac{2}{5}\,\ddot{\mathrm{R}}')\,\dddot{\mathrm{Si}} + 2\ \mathrm{HO}.$$

which upon calculation will yield the following percentage composition.

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* Probably both these oxides contain more or less didymium, which however will probably be in greater part associated with the cerium from the method employed in the analysis.

Silica, ...	30·49
Alumina, (&c.) . . .	13·82
Protoxide of iron, (&c.) .	43·55
Water, ...	12·14
	10·000

VII.—*Calcite.*

Crystals of calcite from Gamle Mjurfjær Iron-mine, at Naesktil near Arendal, were found lining fissures in a granite vein which cuts through the vein of magnetic iron ore.

As the crystals had a very peculiar rather dark brown colour, they were thought worthy of examination. They were well defined and often large crystals, being scalenohedrons, and possessed a specific gravity of 2·75 at 60° Fahrenheit.

They were analysed by the ordinary methods, and a separate portion was examined by means of molybdate of ammonia for phosphoric acid, which was found present in small amount hardly sufficient for quantitative estimation. Magnesia was sought for, but no trace was found present. The results obtained, when tabulated, give the following percentage compositions:—

Carbonate of lime, . .	98·39
„ iron, . .	0·79
„ manganese, .	0·23
Alumina, ...	0·38
Phosphoric acid, . .	trace.
Insoluble, ...	0·21
	100·00

The crystals, therefore, notwithstanding their dark brown colour, contained but a much smaller amount of iron and manganese than might have been expected.

On Insect-Vision and Blind Insects. By ANDREW MURRAY, Edinburgh.*

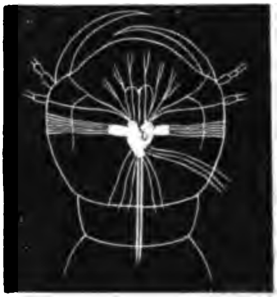
By far the greater majority of insects are born blind—not blind like a litter of pups, because they cannot see—but blind because they have got no eyes to see with. Almost the whole of the Hymenoptera and Diptera, and two-thirds of the Coleoptera, are in this predicament. In fact, all those species which pass their larval state in darkness are thus unprovided. To what purpose would it be, for instance, to furnish the larva of the bee with eyes. It passes its larval life in a dark cell, where it is nourished without trouble or exertion of its own; all it has to do is to open its mouth to receive the food which its kind nurses place in it.† Or what purpose would eyes serve to the nut beetle (*Balaninus nucum*), which wakens to existence in the interior of a hazel nut, where its parent had deposited the egg. Its food is beside it. It has only to eat; and by the time it has finished the kernel its larval life is finished too, and it passes into the chrysalid state. Eyes, therefore, to these, and such as these, would be useless, and they are dispensed with at that period of their existence. On the other hand, those caterpillars which have to seek their food in the light of day, as the larvæ of Lepidoptera and of the predaceous beetles, are provided with eyes, but they are not eyes like the compound eyes of the perfect insect; they are minute specks, termed ocelli, and are placed in varying numbers and varying positions on each side of the head. These are the eyes which we find in the spider, and in some crustaceans; and sometimes insects in the perfect state are provided with two or three of them in addition to

* Read before the Royal Society of Edinburgh, April 6, 1857.

† The larva of the bee has a minute conical tubercule on each side of the head, which was supposed by Swammerdan and Walkenaer to be the rudimental eyes of the perfect insect; and Müller (probably on their authority) states it broadly, that "the larvæ of Hymenoptera are for the most part destitute of eyes, but the larvæ of bees have two simple eyes" (Müller's *Physiology*, vol. i., p. 115); but Mr Westwood correctly points out that these tubercules must rather represent the antennæ, as they appear to be articulated near the base and the tip (Westwood's *Introduction to Entomology*, vol. ii., p. 25), and therefore the bees form no exception to the general rule found in the Hymenoptera.

their compound eyes. The structure of these simple eyes, or ocelli, seems to be somewhat various. In the eye of the *Salticus æneus* (one of those spiders which have the singular property of running backwards or forwards, or in any direction, without turning) we find a nearly spherical lens, covered by or passing into the chitonous structure of the integument, behind which are found the ends of the nerves, with a black pigment or choroid passing round them, terminating behind in the retina. The eye of the scorpion is somewhat different. In it we have a spherical lens behind the cornea, or integument, behind it a lenticular vitreous body, lying in the cup-shaped retina, and the black pigment or choroid surrounding the lens. The optic nerve which supplies these simple eyes runs from the cephalic ganglion in a bundle or united mass of filaments for a certain distance, and then breaks up into a separate nerve or filament for each simple eye, as exhibited in figure 1, which shows the nerves of the head of the larva of *Dytiscus marginalis.** In the caterpillar without eyes no nerve or filament given off from the cephalic ganglion towards the place where the eye should be. It will only be developed from it when it is required; and it would appear that in one particular anomalous group the optic nerve must be at one time developed, afterwards lost, and finally restored. Erichson, in his last work, "Naturgeschicht der Insecten Deutschland," vol. iii., records the observation, that in the Cerambycidæ the larva in its youngest state possesses eyes, but loses them as it becomes older, and after passing through the chrysalid state acquires perfect compound eyes; thus apparently contradicting the statement made by Blanchard ("Annales des Sciences Naturelles," 1846, p. 283), that the organs of insects do not modify themselves sensibly during the life of the larva, but only grow. What the reason of this strange anomaly may be it is difficult to say; possibly—(the Ceramby-

Fig. 1.



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* Copied from Blanchard's figure in "Annales des Sciences Naturelles, 1846."

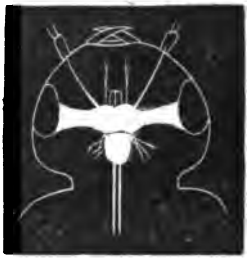
cidæ being wood-feeders)—that the eggs are laid on the bark, outside of the tree, and the young larva may have need of eyes till it has eaten its way into its heart, when of course they would cease to be useful, and might be dispensed with.

After the larva (whether eyeless or not) has passed into the chrysalis and undergone the mysterious change which then takes place, it emerges (except in a few rare cases to be presently noticed) well provided with compound eyes. What the change is which then takes place, or how it is effected, we only know imperfectly. The best observations on the subject are those of the late Dr Newport, in his paper on the "Nervous System of the *Sphinx Ligustri*," published in the London Philosophical Transactions for 1834. In the larva of the *Sphinx Ligustri* he found that the optic nerves were only two diminutive trunks extending from the sides of the cerebral ganglia, and dividing each into eight filaments, given to the eight minute eyes on each side of the head. "At the period of changing to the pupa state," he says, "there is a deposit of dark pigment very slightly organized at the base of each nerve. As the changes of the insect advance, the optic nerves gradually enlarge at their base; and, when this enlargement has gone on to a considerable extent, the dark pigment is carried forward from the base of the nerves, and exhibits a corrugated appearance around its interior margin. When the changes have farther advanced, the optic nerves are extended of a pear-like form, from the sides of the cerebral ganglia, which they then equal in diameter. The enlargement of the nerves seems to be occasioned by the shortening of the cords which connect the cerebral, with the subœsophageal ganglia and the extension forwards of the nervous substance of the cords within the investing theca, the effect of which is, not to enlarge the cerebral ganglia in a corresponding degree, but to develop the optic nerves by the gradual extension and expansion of the nervous substance within them in the form of successive series of purse-like layers of fibres one within the other.

"When the outer layer has arrived at its maximum of extension, it seems to become perforated at a point corresponding to the central part of the membrane, which is carried forward to become the choroid. The next layer advances, and then the next in succession from within outward, so that the central part of the nerve is the last part developed. The fibres of each series, from being bent like the segment of an arc, gradually assume a more lineal direction, and diverging from the axis of the eye, the whole nerve, when completed, forms a series of flattened pear-shaped cones, one within the other, the apices of which constitute the base or origin of the nerve next the cerebral ganglia."

This is the process which was observed by Newport in the case of a larva possessing simple eyes, and from it we can form an idea how the process is conducted in the larva which has no eyes at all, although observation of their changes has not yet been extended to them.

Fig. 2.*



The appearance of the nerve in the perfect insect is shown in the following figure of the nerves of the *Creophilus maxillosus*; and it will be observed that it is now one solid large compacted nerve, applied to the back part of the eye. There is, however, one curious exception to this state of it in the perfect insect. Many insects pass their lives in dark and secluded places, avoiding the light; as, for instance, the *Blapsidæ*, *Tenebrionidæ*, and one or two species of other families (*Pristonychus elegans*, Dej., *P. elongatus*, Dej., *Homolata spelea*, Erich., &c.) which are found pretty far in in the caves of Carniola, though not so far as the eyeless insects of which I shall presently speak. Now, in these the eyes are not only very small, but also very slightly raised above the surrounding surface, in marked contradistinction to those species which affect the glaring and brightest sunlight, as the Cicindelidæ, which have the eyes excessively prominent; and on examining the optic nerves in these lucifugous species, we find that it is not a solid compacted nerve, but that it is like the nerve leading to the simple eyes in the larva,—solid at the base, but afterwards broken up into a number of separate filaments,—as shown in this figure of the optic nerves of the perfect *Blaps mortisaga*, or churchyard beetle.

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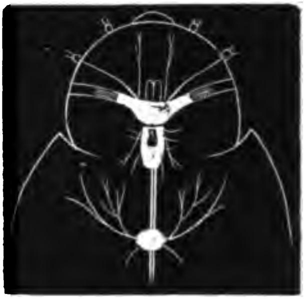
* Copied from Blanchard, *loc. cit.*

The effect of this must undoubtedly be to diminish the vision of the insect; though why it should be diminished because the animal lives in dark places, does not at first sight very well appear. It would rather appear to us that it had need of a larger eye than of a smaller one, to make up for the loss of light. If the animal were to live in total darkness, we can understand why eyes should be dispensed with altogether; but, if eyes are necessary for it at all, would we not say that the greater the darkness the greater the power of the eye should be. Such would appear to be the inference which any analogies we can draw from the vertebrate kingdom would present. There the eye is enlarged, and endowed with greater power, when the animal has to pass its active hours in the dark. The owl, the tiger, and its congeners, are familiar instances. To be sure we have the mole, which may be cited as an example in the opposed sense; but it is scarcely a fair example, inasmuch as its manner of life necessarily requires the complete protection of the eye, and we do not know to what extent it is gifted with the sense of sight, its eyes being supplied by the fifth pair of nerves instead of the optic nerves. The explanation which I am disposed to give of the peculiarity in this class of insects is, that the sense of sight is not less acute in the one than the other insect, but merely more limited. Each filament of the optic nerve will doubtless perform its duty as well when separate as when tied up in a bundle; and what the churchyard beetle does see it will see as well as another, only its points of sight are circumscribed; for what use to it would an extended field of vision be where the whole prospect is mere obscurity. I therefore look upon the small and flattened eye, supplied with few nerves, of these twilight insects less as a provision or adaptation to the place and mode of life of the insects (though it may be that too), than as an instance of nature's aversion to anything like waste or unnecessary work.

Fig. 3.*



The structure of the compound eyes themselves with which the insect in the perfect state has now become provided, seems wholly different from that of the simple eye, or ocellus, which I have already described. Viewed externally they seem divided into an immense number of facets, of greater or less size, in different insects, and of greater or less size in different parts of the same eye. These facets are not entirely hexagonal, as is generally supposed (or rather taken for granted), but are of various forms, apparently assuming whatever form the position of the neighbouring facets, combined with the curve of the eye, impose upon it, being hexagonal in some parts, pentagonal or quadrangular in others, and frequently of an irregular angular form. The prevailing form differs in different insects,—being, for instance, oblong or square, with the corners very slightly filled up or cut off, in the dragon-fly; hexagonal in the butterfly; and so on. These facets are sometimes so small as to be scarcely perceptible. In many of the larger Dynastidæ they are so minute as to make the globe of the eye appear quite smooth and homogeneous; others are coarse and well marked; and these variations occur to such an extent, and are so constant in different families, that they have been successfully used by Professor Lacordaire in his monograph of the Erotylidæ as generic distinctions. It would be long to tell of the different modifications the exterior of these eyes assumes; how some, as the common hive-bee, have the eyes pilose, the hairs being inserted in the corners between each facet (acting possibly as eye-lashes, or rather eye-protectors); how some, as in the dragon-fly, have their structure deep, while others are shallow; how some have their eyes resplendent with golden or silver lustre, while others are opaque. It will be sufficient to say, that these facets are numerous in all, but perfectly surprising in number in some, varying from 50 up to 25,000.

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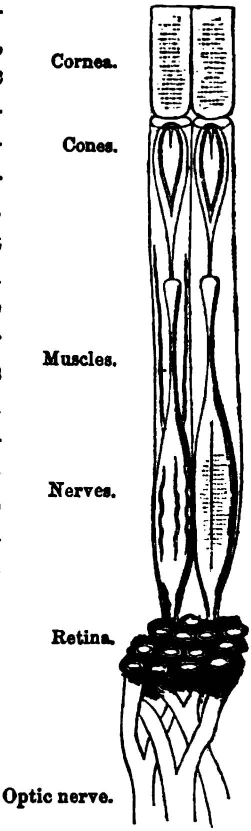
* Copied from Blanchard, *loc. cit.*

A transverse section of a compound eye shows that it is composed of transparent cones, each terminating in one of the facets of which I have been speaking, having very much the appearance of a multitude of telescopes, pointed outwards in every direction. M. Leydig, however, gives a better view than any we have previously had of the intimate structure of these telescopes, in his recent work on Histology, from which I have taken the following figure showing two of the eye-tubules of the eye of the *Procrustes coriaceus* highly magnified. The cornea or chitonous integument is outermost; in it can be traced indicationsof the layers of the chitonous substance of the integument; behind this is a long tube surrounded with pigment, terminating in the retina, behind which, again, lie the bundles of filaments of the optic nerve; from the retina proceeds forwards up the tube a ganglionic structure, having two ganglionic enlargements, and inclosing filaments of nerves. A muscle lies on each side of it, and it ends in a quadrangular cone-shaped body, having its base applied to the facet, and its apex towards the interior of the eye. At first sight there does not appear much resemblance between this eye and the human eye; but physiologists were determined to find analogies and homologies, and of course such were laid down. It is only recently, however, that discoveries have been made which would seem to furnish a clue to the true homologies of the eye in insects. Hitherto the analogy has always been attempted to be drawn between the entire eye of the vertebrata and the eye tubules, or so-called individual eye, in the compound eye of insects; and the generallyreceived opinion is that which is stated by Professor Owen in his "Comparative Anatomy of Invertebrate Animals," (edition 1855); that the conical body was the equivalent of the crystalline lens and vitreous humours. Dr Carpenter has carried the attempt to find analogies farther, having in his "Comparative Physiology," (edition 1854,) pointed out the equivalents of the iris and the aqueous humour, as well as the crystalline lens. The recent microscopic researches of various eminent physiologists give us reason to doubt that these analogies or homologies are founded in fact. The error has arisen wholly from comparing each of these small portions of the compound eye of insects, with the entire eye in the vertebrate animal. If instead of com-

Fig. 5.



paring a portion of the one with the whole of the other, we compare the entire compound eye with the entire eye of the vertebrata, we shall at once see that the analogies so long drawn must be abandoned. The eye of the vertebrate animal is a hollow globe, with only one small aperture for the admission of the visual rays; and as not merely one minute point exactly opposite to the aperture is to be impressed on one point of the sensorium of vision, but a large extent of view on every side is to be impressed over a large extent of sensorium, special optical apparatus and contrivances are required for this purpose;—we have the iris to regulate the admission of light, the crystalline lens to converge the visual rays, the ciliary ligaments to adjust its focus, the vitreous humours to disperse the rays,—all necessary (in consequence of the form of the eye to which I have alluded) to produce on the sensorium the correct impression of the object seen, but none of them, as I understand it, necessary for any other purpose than to overcome the difficulties arising from the cave-like form of the eye. Had the eye been retroverted, for instance,—turned inside out like a glove,—the sensorium would then be exposed to the direct impression of the visual rays all round, and would need neither pupil nor iris, crystalline lens nor vitreous humour. It is not my business here to show why the eye is better as it is, any more than it is to show in what respects the eye of the vertebrata is superior to the eye of the insect. It is sufficient for my purpose to show that the above inverted position of the eye corresponds to the position of the so-called compound eyes of insects. Looked at in this view, we must,—if we are to seek the homologues of the eyes of insects in the eyes of the vertebrata,—put aside all these accidental parts (if I may so call them), and prosecute our search in the parts deeper seated, and forming what may be called the ultimate portions of the eye; and the microscopic researches to which I have alluded have revealed a structure which appears at last to give us their true homologues. Professor Goodsir brought these discoveries before the physiologists of Edinburgh in an interesting lecture which he gave on the structure of the retina about two years ago (and of which an abstract will be found in the "Edinburgh Medical Journal," Oct. 1855. See also Proc. Royal Soc. in present number of this Journal, p. 156).

I shall not occupy the time of the reader in recapitulating these discoveries further than simply to say, that what used to be called the retina has been proved to be composed of several layers, which have been distinguished as the bacillary (fig. 6, *a*), the white cellular, in three strata (*b*), the grey cellular (*c*), the filamentary (*d*), and limitary layers (*e*), reckoning from behind forwards. These structures are shown in fig. 6.

Fig. 6.

The layer which interests us the most is the bacillary, which is composed of rods and cones, and which Kölliker ascertained, by process of exhaustion, to be in all probability the structure on which objective light first impresses itself.

It will at once be seen that there is a great resemblance between the bacillary layer, containing rods and cones, and the conical-shaped bodies arranged behind the facet of the eye in insects (fig. 5, *b*). The arrangement of the rest of the structure furnishes also other points of resemblance—the prolonged filaments in the white cellular layer remind us of the prolonged stalk on which the conical bodies rest; and the filamentary layer, which is composed essentially of the ultimate filaments of the optic nerve, seems to correspond to what Leydig calls the retina in the insect. On all these points there seems a resemblance; but there is one awkward circumstance, which at first sight would seem to upset all our conclusions. I have placed the figures with the rods and conical bodies both looking outwards, in order that the resemblance between them may be more apparent; but in nature they are not so placed. There their position is reversed. The conical bodies are next the light in the insect—in the vertebrate animal they are farthest away from it. If placed as they really stand, one of the figures should be turned upside down. Here is a difficulty which makes us pause upon the very threshhold. But we are relieved from our dilemma by a happy conception of Brücke and Hannover, made apparently without any reference to the eyes of insects (and therefore more trustworthy for our purpose), and suggested rather by the difficulty of accounting for the portion of the retina on which objective light first impressed itself being placed farthest away from the light. They conceive that the light passes through the whole coats or layers of the retina, which are all perfectly transparent, and is reflected back again by the rods and cones of the bacillary layer. Professor Goodsir improves upon and extends this idea. He suggests that "the divergent pencil of light which proceeds from any visible point to the eye, becoming convergent after having entered the refractive media, passing through the perfectly transparent retina, is probably brought to a point at the surface of the choroid or outer part of the bacillary layer of the retina, and is not entirely absorbed there, but is reflected as a divergent pencil." In other words, that the eye is looking backwards, and sees images reflected as in a mirror; and if we suppose the structure which we see in the front of the eye of an insect to be continued all round to the back, and then the front part to be removed or absorbed, we have exactly the structure which we find in man, merely substituting the cones and rods of the latter for the conical bodies in the former. The arrangement is the same in both, only the insect is, as it were, looking at the landscape out of a window, while man has his back turned to the window, and is looking at the landscape in a mirror. In the insect the visual ray enters each facet; in man it impinges on the truncated ends of each of the rods in the bacillary layer. The effect of this is, as Professor Goodsir puts it, that "the human sensorium receives from the retina the impression of a picture which is not continuous, but made up of detached points; as in the vision of the insect which only sees an object by as many points as can transmit rays along the axis of its eye-tubules." Thus it would appear that both see by what Müller called "mosaic vision."

The foregoing is the structure which almost universally prevails in insects. But there are a certain number of anomalous insects which live in the dark, and which are altogether unprovided with eyes. Some of these are found in ants' nests; others in subterranean places, under leaves, bark, and decaying vegetable matter; and others, again, only far in the interior of caves. A rapid glance thrown over them will not be without interest.

It is only within the last few years that ants' nests have been searched for other insects than the ants themselves. But it is now found that many such pass their whole lives in these nests; and various species hitherto unknown have been found by searching these. Ants' nests are therefore popular at present; and not the less so, that some of the new species which have been found in them are blind. These, and all species which live entirely in ants' nests, wear the same livery as their hosts, and not only so, but very often assume much of their form. The commonest of the blind insects found in ants' nests is the *Claviger testaceus*, Preyss., which is found throughout Europe. Two other species have been described: one, *C. longicornis*, Müll., also found in Europe; and *C. colchidicus*, Motsch., from the Caucasus. This genus is represented in North America by an insect named *Adranes cæcus*, described by Leconte, and it also lives in ants' nests.

Another group of blind insects are found under ground or under stones, &c. The first which I shall mention is a small beetle belonging to the predaceous group, the Bembidii. It was recently discovered near Bordeaux and Toulouse, and described by M. Jacquelin du Val under the name of *Anillus cæcus*. M. du Val's specimen was taken under large stones which lay buried beneath a dunghill, or rather a large bed of decaying straw. Notwithstanding its want of eyes, M. du Val describes it as very agile, which is the character of all the Bembidii. Besides this, there have been found under ground a number of minute Clavicornes without eyes,—*Aglenus brunneus*, Gyll.; *Anommatus* 12-*striatus*, Müll.; *Clinidium Guildingii*, Kirby, and *sculptilis* of Newm.; *Langelandia anophthalmica*, Aubé. The latter is specially found on stumps of stakes or posts which have stood long in the ground. This is perhaps the place to take in two species recently described by Fairmaire, of whose habits we as yet are ignorant,—the *Amaurops Aubei* from Sicily, and the *Leptomastax Coquereli*—a very singularly formed species, allied to the Scydmænidæ, taken on the sands of the Bay of Beikos during last campaign.

Another group of blind insects are found under leaves and decaying vegetable matter. They are confined to two or three genera. The first (*Ptilium*) is curious as containing the smallest species of beetle known, and as having some of its species blind and others provided with eyes; and yet, so far as we know, there is no difference in the habits of life of those with eyes and those without them. When the eyes are awanting, they are replaced by a small tubercle, from which springs a long hair, which may possibly serve something of the same purpose as the tiger's or cat's whiskers, which are understood to be serviceable to these animals in moving in the dark,—a provision which we shall see strikingly reproduced in one of the genera of cave insects. The blind species of Ptilium are *Ptilium aptera*, Guer., and *microscopica* and *angustata* of Gillmeister, who has published a very careful monograph of this minute genus. The remaining blind genera which have been found under leaves and in forests, are *Leptinus*, the single species of which, *L. testaceus*, Müll., has been found in Britain, though very rarely; and *Adelops*, a number of species of which (all blind) are now known, and which possesses an interest peculiar to itself, from containing species which are found in the caves, as well as species which are found under leaves in forests. The species found in the latter localities are *Adelops Schiodtei*, *Aubei*, and *ovata*, Keis., and *meridionalis*, Fairm., all found in the Pyrenees and south of France; *Khevenhulleri*, Müll., near Vienna; besides a new species which Mr Jansen last year discovered near London.

I now come to the troglodytes, or cave insects. It is a long time (nearly a century) since the curious blind reptile, the *Proteus* (now *Hypochthon*) *anguinus* was discovered in the caves of Carniola; but although the occurrence of one animal so singularly adapted to its condition of life, might naturally have suggested the idea that others with a like structure would be found there also, if sought for, still it is only within a comparatively recent period that it has been ascertained that various eyeless insects and crustaceans also inhabit these vast subterranean solitudes.

The first insects which were found were a small crustacean of the Oniscus tribe, described by Kock in 1840 under the name of *Pherusa alba*, and a beetle, described by Sturm in 1844 under the name of *Anophthalmus Schmidtii*. Schiodte next visited the caves, and discovered eight new animals, and in 1851 published a very interesting account of his researches, and of the animals which were found in the caves. About the same time similar discoveries were made in America in the great Mammoth Caves of Kentucky. In 1842 the blind fish *Amblyopsis spelæus* was discovered, and afterwards blind insects also. Subsequent researches in Europe have also successively brought to light other species. Besides the *Anophthalmus Schmidtii*, we have now four other European species; and, it is to be observed, that so far as our information yet goes, they appear to be confined each species to its own cavern, or rather district of caverns;—*Anophthalmus Schmidtii* from the cavern of Luege, near Adelsberg, in Carniola; *A. Bilimekii* from the Sele Grotto; *Scopolii* from the Grotto of Setz, in Carinthia; and *Hacquetii* and *hirtus* from the Grotto of Kirmberg, near Oberiggdorf. Each district would appear thus to have its own species,—a circumstance (if confirmed) interesting, in relation to the theory of single centres of creation. The *Pherusa alba*, no doubt, is found in all the caverns of Carniola; the *Leptodirus Hohenwartii* in several; and so on; but these caverns are close together, and probably connected with each other by internal passages. It is curious that these creatures are only found far in the interior of the caverns, and never approach the garish light of day, which would appear to be as effectual a barrier to the dispersion of the species from one unconnected cavern to another as the highest mountain or widest ocean is found to be in the upper world. One does not well see why these blind animals might not, as it were, lose their way, and occasionally stammer upwards into broad daylight. Had they had sight, however feeble, the light might have been painful to them, and kept them in their native darkness; but if they have no perception of light, such a check would not operate. But I shall recur to this point when I come to speak of the structure of the places where the eyes should be.

But if the specific distinctness of the species peculiar to each cavern strikes us with interest, their generic identity is not less wonderful. Here in each cave we have a species so like those in the others (though still distinct), that we involuntarily ask ourselves what is the peculiar virtue of this form, as adapted to its condition of life, that the changes should be thus rung upon it in every cavern in Europe; and while we puzzle over it, lo! the caves of Kentucky are examined, and another new species is brought from them,—an *Anophthalmus* too, and as close in form to the European species as those of the one cave are to those of the next. I cannot suggest any plausible explanation why this particular form should be selected as most suitable for the condition of life of these insects (for that it is most suitable, cannot, I think, be doubted,—Nature not only always doing everything well, but everything best). To our finite perception, not only is the purpose of the form of the insect undiscernible, but its existence in its sphere of life at all would almost seem to be a mistake. It is one of the predaceous carnivorous Coleoptera coming in our arrangement next the agile group of *Trechus;* and unless we assume that it is provided with some special sense which compensates for the want of light and want of sight, it does not need much consideration to satisfy us that its hunt after its prey will be the pursuit of food under difficulties; and that it does not live on very full commons may be inferred from the state in which we find it,—the whole of the inside, in any I have seen, being shrivelled up into almost nothing. Still they live; therefore must be fed, and must, I think, be possessed of some additional instinct or increased power in the other senses, to enable them to procure the wherewithal. What is that additional or increased sense? Is it that of smell? Entomologists are not yet of accord as to the seat of that sense, some maintaining that the antennæ are its organs, while others maintain that they are the organs of touch, and others again the organs of hearing; and most striking evidence has been brought forward by the advocates of each in support of their particular view,—evidence so conclusive, that I acknowledge I have been convinced by all three, and I do most potently believe that the antennæ are the seat of all three senses, so that we may not only say that, like a Scotchman, the insect *feels* a smell, but it also hears a smell, and smells a sound. How does the structure of the antennæ of the *Anophthalmus* affect the question? They are considerably longer than usual in the group to which they belong, but are not thickened or expanded, which is the form we see adopted in those insects where the sense of smell is to be specially developed, as in those which have to smell out putrid or fetid matters on which to feed. It would not appear, therefore, that they hunt by the sense of smell. The sense of hearing is the sense which, among our own blind, becomes most useful, and I think we may reasonably infer that the same is the case among these blind insects. Sensitiveness of touch will no doubt be increased; and we see on the *Anophthalmus* that there are several excessively long, stiff hairs projecting on each side of its body, which may be used for the purpose I have indicated in speaking of similar hairs on the blind *Ptilium*. This can, however, only be a very subordinate assistance; for we have two other blind predaceous animals, two Arachnideæ, which are not furnished with such long hairs (the *Stalita tæniaria* and *Blothrus spelæus* of Schiodte, *Obisium troglodytes*, Sturm.) The remaining troglodytes belong chiefly to the family of Clavicornes. The cave species of the genus *Adelops*, which I have already spoken of as possessing some species which are found under leaves in the forests in the Pyrenees, are *Adelops byssina* and *montana*, Schiodte, from the caves of Carinthia; and *Adelops hirtus*, Tellkampf, from the Mammoth Cave of Kentucky; another instance of the same form, though not the same species, being reproduced in both countries. Another genus, *Leptodirus*, is interesting from its form, which has little affinity with any other genus, although it approaches most nearly to *Mastigus*. Three species of this genus are known,—*Leptodirus Hohenwartii*, from the Grotto of Adelsberg, *angustatus* from the Grotto of Volija Jama, and *sericeus* from the Grotto of Cuba Dol. The *Adelops* are extremely agile, notwithstanding their want of eyes. The *Leptodirus* are less so. The still more recent discovery of a blind Curculionidous species, allied to *Otiorhynchus* and described under the name of *Troglorhynchus* (Verhandl. des Wiener Zool.-bot. Vereins, Bd. iv. S. 62), and of a Brachelytrous species (allied to *Oxyporus*, according to H. Müller (its discoverer), and to *Pæderus*, according to Kraatz), and named *Glyptomerus cavicola*, Müll., completes, I think, the tale of blind cave beetles.

The food of these insects remains to be considered. So far as regards the carnivorous species, there is no difficulty in guessing what their food is. It must be the other smaller and less powerful species which live beside them; but what do these, in their turn, feed upon. Schiodte supposes them to feed on a Byssus which clothes part of the walls of the grottos. But H. Müller of Lippstadt, in an account of his researches after them last summer, published in the "Stettiner Etom. Zeitung," xviii. (March 1857), narrates that he found the *Leptodirus Hohenwartii* in stalactitic chambers, constantly wet and dripping, which would not furnish much nourishment; but he found that there were numerous morsels of corrupted and blackened wood lying on the ground, and he believes that it was upon these that they fed. Schiodte and Müller both consider water in the caves to be essential to their life; and it may be that it is by means of water that such fragments of wood have been, and are still deposited in the caverns. The *Troglorhynchus* also was found in caves whose bottom was covered with humid earth.

Besides the species already mentioned, there is a species of Thysanoura found in these caves—*Anurophorus Stillicidii*, Schiodte; and there are several blind crustaceans both in the caves of Carniola and those of Kentucky, as well as a number recently found in deep wells in this and other countries. These, however, do not fall within the scope of this paper, so I shall not occupy the time of the reader in enumerating them.

At one time it occurred to me that we might have some blind species in our own caves; and about two years ago, I took advantage of being on a visit in Derbyshire to make a thorough search through one of the largest natural caves in that porous county, viz., that known as the Blue John Mine, from which is extracted the beautiful purple fluor-spar, of which the so-called Derbyshire spar ornaments are formed. The mine is a natural cavern, in parts of which the spar is wrought for. It descends obliquely, by rifts and crevices, for a very considerable distance, occasionally opening up into lofty caves or halls, as the manner of such places is. After passing the part of the cavern where the path has been smoothed and made practicable for the visitor, the wildest confusion reigns. Great angular blocks of stone, slippery with slime and clay, lie piled up in continued streams; here and there all access appeared barred, and we only prosecuted our way by creeping on our bellies through little narrow holes in the clayey barriers, such as only a vision of an *Anophthalmus* on the other side would ever have tempted me to risk sticking in. Sometimes up, sometimes down; now trying a rift running to one side, then a crevice to the other; every nook and every alley was faithfully explored; but alas! nothing blind found but the alleys. I mention these particulars to let any one who has a fancy for the same adventure see that "the gambol has been shown"—that I did not limit my exploration to the ground usually viewed by tourists, and that it will be better for any one who wishes to repeat such an examination to select a different cave for the purpose. Indeed, we can scarcely expect to find any troglodytes in this cavern, for, as I have already mentioned, the species in the Carniolan caves do not occur within two miles of the mouth, while here I do not suppose, that at the very farthest, we penetrated more than half a mile into the bowels of the land.

I am afraid I have already exceeded the space allotted to me; but I feel that any paper treating of blind insects would be imperfect if it took no notice of the peculiar structure in which their chief interest lies, viz., their want of eyes. I am not aware that anything has yet been done by others in relation to this. I believe not; the extreme rarity and value of these minute creatures operates as an obstacle. I have, however, sacrificed one of my specimens of *Anophthalmus Bilimekii*, in order to see if anything could be gathered from an examination of the interior of the head; and I think that, notwithstanding the disadvantages arising from the *dryness* of the *subject* (if I may use the words both in their literal and anatomical sense), I have observed something which it may be worth while to notice. The head of the *Anophthalmus* consists of two great lobes engrossing almost the entire surface of the head. Simple inspection, I think, shows that these occupy the space which was intended for the eyes.* On looking into the inside of the head, I find, of course, all the soft parts desiccated and undecipherable; but the inner surface of the chitonous integument showed this interesting peculiarity. Under a high power of the microscope, I found the thorax to be wrinkled transversely, with an immense number of angular elongate cells, like the cells in vegetable structure, which I believe to be the normal structure of all chitonous substances. This structure is shown in fig. 6, which represents a portion of the inner surface of the thorax. Bringing the interior of the ocular space under the microscope, I find the same cells, but greatly more developed (fig. 7). The power which shows the cells in the head very distinctly does not allow us to see the structure of the thorax at all. Dr Greville has been kind enough to execute the drawings of figs. 6 and 7, so that there can be no doubt as to their accuracy. The scale only is some whatdifferent, fig. 7 being on a smaller scale than fig. 6.

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* The eye-space is not always thus well marked out. It is so in all the *Anophthalmi*. Kirby, in his description of *Clinidius Guildingii* in the "Zoological Journal," 1832, dwells upon it in that species; but in others, as *Adelops*, *Claviger*, *Aglenus*, &c., there appears no eye-space at all, but the whole of the head is of one uniform surface and texture.

Fig. 6.

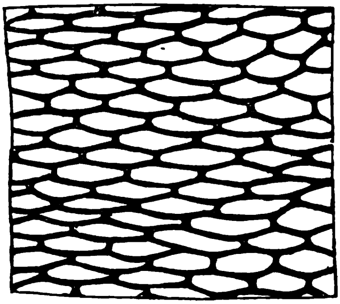
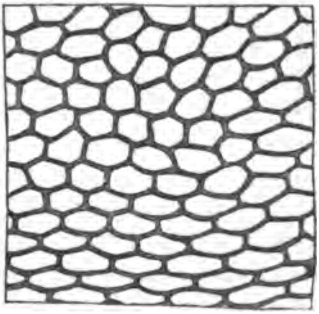


Fig. 7.



It will be observed, also, that on the thorax and at the back part of the ocular space, the chitonous cells are long and transverse; as we approach the centre of the ocular space, they begin to assume more of the usual hexagonal form of the facets of the eye, till in the centre we see some facets which are almost of the normal shape. This may possibly arise partly from the necessities of the rounded form of the eye space; and Dr Greville thinks he sees a tendency to an approach to the hexagonal form even in some parts of the thorax. I do not pretend to say positively that the structure on the ocular spaces of the head of the *Anophthalmus* is an atrophied or abortive eye; but I may at least say it looks very like it; and supposing it to be so, it gives us an instructive insight into the mode of development of the outer surface of the eye. We see that it is only a slight modification of the normal structure of the integument, and the tendency seen by Dr Greville towards a similar structure in other parts than the eye-space, is peculiarly interesting, as showing, that so far as the integument is concerned, there is no particular condition necessary for its development into the cornea, but that it might be equally easily constructed upon the thorax as upon the head. And this is in entire accordance with what is already known regarding the development of the eye in the vertebrata. In them the eye has been satisfactorily proved to be merely a part of the skin altered and added to; for instance, the state of the eye of man in its earliest stage is simply a fold of the skin.

In all this, and indeed throughout the whole of this paper, I have been proceeding on the assumption that these insects are destitute of the power of vision. But this is merely an assumption, which may be only partially true. We know that the *Proteus anguinus* has an eye under the skin, and a not wholly atrophied optic nerve; and we are told that when flambeaux are brought near it, and an attempt made to catch it, it usually darts off for some distance, where it rests, and is more easily caught the second attempt. In like manner, Schiodte says of the *Leptodirus*,—"The animal moves slowly and cautiously, supported on its long legs as if on stilts; it stands still the instant that light, or rather the sound of approach, reaches it, when it crouches down and remains immoveable, with erect antennæ and stretched out legs, unless it is touched." No doubt the above incidents may be explained without supposing light to have any effect upon them. The noise of the visitors, the disturbance of the air by their presence, and torches, &c., may sufficiently advertise them of the intrusion of foes; or if light has any effect upon them, it may be that the structure of the ocular space in the Anophthalmus is of a parallel nature to the eye and optic nerve of the Proteus; or, failing this, it may be that, like plants and zoophytes, they are sensible of the influence of light without possessing eyes. Notwithstanding this, I imagine there can be little doubt that their powers of vision must be so feeble as to justify us in looking upon them and calling them blind.

REVIEWS AND NOTICES OF BOOKS.

Encyclopædia Britannica: Dissertation Sixth, exhibiting a General View of the Progress of Mathematical and Physical Science, principally from 1775 *to* 1850. By JAMES DAVID FORBES, D.C.L., F.R.S., Sec. R.S., Ed., Professor of Natural Philosophy in the University of Edinburgh, and Corresponding Member of the Institute of France.

The rarest of all the productions of nature we take to be a competent historian of science. The very elements which go to his composition are of necessity paradoxical, and, unless wonderfully blended and tempered, are likely, from man's natural anxiety for self-elevation, to lead their possessor to aim at discovering, rather than at recording discoveries. That he may appreciate genius—that he may be able to distinguish between originality and an aptness to assimilate and work out the conceptions of others, it can hardly be doubted that the historian should be himself a man of original power—should, indeed, have exhibited that power by his own contributions to the progress of science; and yet how generally does it happen, that a consciousness of the position of his own name on the page, draws, with unjust force, his pen towards the spot whence that name may be descried, as though he were writing an introduction which the next generation should complete by the addition of his own biography. The recent life of Newton may, to some extent, explain our meaning. Valuable as it is in reference to Newton himself, we cannot help feeling, when we are reading the account of his optical discoveries, that we are touching also on those of Sir David Brewster. A similar remark will apply to the same author's account of the stereoscope. The very fact of Sir David's high eminence as a discoverer, mixed up as his discoveries have been with those of others, aided too, perhaps, by some little impatience of criticism, renders him, unconsciously, a special pleader when he should be a simple narrator, and thus disqualifies him from being altogether an unexceptionable historian of science. The recorder will, under all circumstances, be blended with the record; and if the topic has engaged him in previous controversy, his judgment will not be wholly unbiassed.

At the same time, physical science, in its present progressive form can hardly be mastered by any but those who partake, to some extent, in its discoveries. A mere compiler will probably be a superficial examiner. Even if he possessed the power, we doubt if any would have the patience to climb to the requisite height, unless he started from a platform created by his own genius.

The author of the work before us belongs to the class of original discoverers—to that of men of genius of the highest order. Happily his range of research has been too wide—embracing every region, from the scattering of the stars in the heavens to the pulsations of heat in the arteries of the earth—to suffer his sympathies to be nailed down to any one or two branches of his subject. Happily, too, his discoveries have generally come before the world in a form so clear, complete, and convincing, that he has been little, if at all, involved in the meshes of controversy. Happily, moreover, he seems to have got scent of what we intended to say about the liability of men of genius to err in recounting discoveries in which they themselves have borne a part; for, on turning to the subject of polarization of heat, we find him commencing that portion of his history with an apology. "The length to which this chapter has already extended must be my apology for bringing concisely to a conclusion what remains to be stated regarding the progress of the subject of radiant heat." (Art. 707.) The length of the chapter! Why, the next chapter is considerably longer. We must return to this subject before we have done.

Spite of all these encouraging considerations, we confess we opened the present Dissertation with some little anxiety. We think the existing generation is not favourable to the production of durable impartial history. Ours is an age of discovery; we do not now mean scientific discovery. For a century or so the habit had prevailed of receiving implicitly the traditions and records of past times, assuming them to have been substantiated at the date of their publication. This style of constructing history consisted merely in breaking up and rearranging stereotype blocks. Recently, the worthlessness of such a mode of proceeding has become apparent, and now the opposite error has come strongly into vogue—that of leaping back to contemporaneous neglected documents, and, on their evidence, reversing the settled deliberate verdict of past centuries. Thus Cromwell and Mary of Scotland, and George of England (we don't mean him of the Dragon) get new characters;—nay, to such an extent is this carried, that, following the example of a learned prelate, we have a worthy man presenting us with "historic doubts" relative to the existence of Shakspeare—a writer of plays. Now, this style of thing is creeping into science. In a work lying before us, entitled "Specimens of the Table Talk of the late Samuel Taylor Coleridge," we read, under the date October 8, 1830, the following judgment:—"It would take two or three Galileos and Newtons to make one Kepler." Coleridge, with all his knowledge, probably knew very little of any one of the three—Galileo, Kepler, Newton; but, had he not seen the famous frescos in the hall of the University of Bonn? and with German spectacles too? Speaking of Kepler, we believe it is the fashion now to attribute more to him than was the custom with our ancestors. We had, some two or three years ago, a life of that eminent searcher after laws thrust into our hands, in which he appears in glorious colours; and almost whilst we write, a contemporary, after the manner of Horrox, commits himself to the following judgment:—" Before all astronomers, we think Keppler* deserves the title of Legislator of the Heavens," (a title frequently, and with justice, given to him). "Besides his three laws, he certainly did as much in the discovery of gravitation as Newton did; some think more." We do not know whether this writer, too, gets his information from German pictures or not, but, if he will consult the works of Kepler, he will perhaps admire him more and exalt him less. The untiring energy which could grapple with such apparently hopeless masses of materials, and build them up into goodly symmetrical structures—the faith in the existence of simplicity, amidst infinite complexity which could impel him to devote his life to search it out, proclaim that great man to be a true philosopher: but there was a point beyond which his mind could not penetrate; in optics, in astronomy, he looked for harmonies, for correlations, rather than for laws. Like the bee, he constructed his fabric with wonderful and accurate symmetry, such as his eye loved to look on, but in that symmetry other eyes, aided by other intellects, have discovered an economical adaptation which neither Kepler nor the bee dreamt of.· We are digressing, though possibly our digression may have helped us to strengthen the second of the positions with which we set out, viz., that the historian of science, if he be not also a discoverer, is likely to be only a superficial examiner, and therefore subject to be misled by the tendencies of the age in which he lives.

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* Terpander, we think it was, immortalized himself by adding a seventh string to the lyre: modern biographers and editors may immortalize themselves by adding a seventh letter to the name of Kepler. He is himself immortal, without the aid of the additional *p*. There are, it is true, some of his works in which the seventh letter is employed, no matter whether correctly or not. But, as *Joannes Keplerus*, he was accustomed to build castles with the letters of his name, just as he did with the distances and periods of the planets; and consequently, under that name he should be suffered to rest in peace. The following passage from the life of Kepler, in the Library of Useful Knowledge, made a powerful impression on our imagination thirty years ago. It may be regarded as a mind-portrait of Kepler, painted by himself. " When I was a youth," he says, " with plenty of time on my hands, I was much taken with the vanity, of which some grown men are not ashamed, of making anagrams, by transposing the letters of my name, written in Greek, so as to make another sentence; out of *Ιωάννης Κεπλῆρος*, I made *Σειρήνων κάπηλος*; in Latin, out of *Joannes Keplerus* came *Serpens in akuleo*. But not being satisfied with the meaning of these words, and being unable to make another, I trusted the thing to chance, and taking out of a pack of playing cards as many as there were letters in the name, I wrote one upon each, and then began to shuffle them, and at each shuffle to read them in the order they came, to see if any meaning came of it. Now, may all the Epicurean gods and goddesses confound this same chance, which, although I spent a good deal of time over it, never showed me any thing like sense, even from a distance. So I gave up my cards to the Epicurean eternity to be carried away into infinity; and it is said they are still flying about there, in the utmost confusion, among the atoms, and have never yet come to any meaning. . . . . . . Yesterday, when weary with writing, and my mind quite dusty with considering these atoms, I was called to supper, and a salad I had asked for was set before me. It seems, then, said I aloud, that if pewter dishes, leaves of lettuce, grains of salt, drops of water, vinegar and oil, and slices of eggs, had been flying about in the air from all eternity, it might at last happen by chance that there would come a salad. " Yes,' says my wife, ' but not so nice and well-dressed as this of mine is.' "

We say we approached the Dissertation with some little anxiety. The subjects which it embraces are numerous, widely ramifying and difficult. When we assert that we have read the work, we do not mean it to be inferred that we have weighed each sentence, and considered both its exact import and the grounds on which the author set it down. In this sense, it is reading, not of a day or of a year, but almost of a life. As the record of the discoveries of three-quarters of a century, terminating with the present time, it can scarcely be believed that any man but the author himself, and two or three others, whose range of reading has been as wide as his own, can speak decidedly on every point—can even venture to speak on some points at all. That the work has many blemishes, many oversights, some manifestations of undue leaning to this side or to the other, may be safely admitted—it is a human production, and to err is human. That its blemishes will be carefully sought out, we may venture to predict. Indeed, the very first remark in reference to it, which met our ears, was a complaint of the treatment which Mr Fairbairn has received in the matter of the tubular bridge. We had intended to judge of the merits of this question by reading through Mr Fairbairn's own statement. We went so far, indeed, as to read the title-page, and we give the reader the benefit of our researches. "An account of the Construction of the Britannia and Conway Tubular Bridges, &c. &c., By William Fairbairn, C.E." But here we paused, and finally resolved that here we would pause. What have we to do with Mr Fairbairn and Mr Stephenson? True, had we found on examining those parts of the work with which we have most right to be familiar, that a general tone of one sidedness, a tendency to exalt this man and to depress that, to pass hastily over important branches of science that others less important might be brought into prominent notice—had we found such to be its tone and tendency, we should have raised our voice against this Dissertation being received as the exposition of the progress of Mathematical and Physical Science. But we find nothing of the kind; we are. on the contrary, impressed with the clear, healthy spirit which pervades the whole work. The author's scientific attainments place him in an atmosphere above the current where the straws and motes of the present day are floating, which an ordinary writer would have greedily caught at; and from this height he has looked on the past century with the broad and kindly gaze of one who himself awaits the judgment of succeeding ages.

The Dissertation is divided into seven chapters—the first introductory; the second and third on astronomy; the fourth on mechanics with its applications; the fifth on optics; the sixth on heat, including some topics of chemical philosophy, and the seventh on electricity and its cognates.

The introductory chapter is a very admirable inquiry into the limits of the science of natural philosophy, and the relations which exist between it and mathematics on the one hand, and the mechanical arts on the other The following passage will give the reader a just idea of the spirit in which the work has been conceived and executed :

"It seems to me impossible to exclude from a review, however slight, of contemporary progress in the exact sciences, the advantages which have accrued to them, both directly, and as it were reflexively, by the astonishing progress of the mechanical arts. The causes, indeed, which called them forth are somewhat different from those which are active in more abstract, though scarcely more difficult, studies. Increasing national wealth, numbers, and enterprise, are stimulants unlike the laurels, or even the golden medals, of academies, and the quiet applause of a few studious men. But the result is not less real, and the advance of knowledge scarcely more indirect. The masterpieces of civil engineering—the steam-engine, the locomotive-engine, and the tubular bridge—are only experiments on the powers of nature on a gigantic scale, and are not to be compassed without inductive skill, as remarkable and as truly philosophic as any effort which the man of science exerts, save only the origination of great theories, of which one or two in a hundred years may be considered as a liberal allowance. Whilst, then, we claim for Watt a place amongst the eminent contributors to the progress of science in the eighteenth century, we must reserve a similar claim for the Stevensons and the Brunels of the present; and whilst we are proud of the changes wrought by the increase of knowledge during the last twenty-five years on the face of society, we must recollect that these very changes, and the inventions which have occasioned them, have stamped perhaps the most characteristic feature—its intense practicalness—on the science itself of the same period." (Art. 11).

In treating his subject, it has been the author's aim to blend the personal with the scientific Accordingly, in the subdivision of the work into sections, he has allowed the biographical principle to predominate, thus giving as much as possible a historical character to the whole, and endeavouring to introduce the reader to the intellectual acquaintance of the eminent men who are selected for notice. (Art. 23). We regret that our limits do not permit of our extracting one of these biographies in full as a specimen. We shall content ourselves with giving a few passages from the combined notices of Leverrier and Adams in reference to the planet Neptune.

"We have now to chronicle a discovery, which, by general consent, stands first in the achievements of science, not only in the period now under review, but even in the long and eventful series of years which have elapsed since Newton established the doctrine of universal gravitation.

"The discovery of which we speak was no less than the proof of the existence of a planet beyond the recognised boundary of our system, merely as an inference from the perturbed motion of the outmost planet Uranus; a proof, not general or abstract, but particular and specific: 'Look, on such a night, and in such a direction, and there you will see by the telescope a star, small, indeed, but with a distinguishable disk,—*that* is the planet which has made Uranus move so unsteadily in its orbit,'—so spoke the mathematician; and the zealous astronomer to whom the call was especially addressed, pointing his glass to the sky, discovered at once, that is, the same evening, a body answering, *almost precisely*, in position as well as in brilliancy, to the oracular announcement.

* * * *

"M. Leverrier is, we believe, a native of St Lo in Normandy, a province which has been singularly productive of eminent men (Laplace and Fresnel were of the number). With no advantages, but the reverse, he won a high position at entering the polytechnic school, which he constantly maintained. He at first, we believe, attached himself to chemistry, but his taste for physical astronomy was soon developed, and was advanced entirely by his private efforts. It is a peculiarity of the mode of cultivating the sciences in Paris, that such abstruse and difficult studies are not merely engaged in temporarily for purposes of academical distinction, but that they actually become a 'carrière' or *calling*, and are pursued in that methodical manner for which the French are distinguished. In 1845, when he commenced the careful examination of the theory of Uranus, M. Leverrier was already favourably known by his researches on comets, and on the orbit of Mercury, but especially by immense calculations connected with the secular inequalities of the planets, by which his ability and hardihood in computation had been thoroughly exercised.

* * * *

"On the 1st of June 1846 he announced to the Academy of Sciences that the true longitude of the expected planet, for 1st January 1847, was 325°, with a probable error of 10° This result was immediately published in the *Comptes Rendus*.

"Between the 1st June and 31st August 1846, when his third memoir on the perturbations of Uranus appeared, M. Leverrier busied himself in obtaining a farther approximation to the elements and place of the suspected planet. He now assumed the correction of the mean distance amongst the other quantities to be sought. By a fresh calculation he deduced a complete list of elements as regards longitude; and diminished the mean distance considerably.

* * * *

"No one who read at the time the abstract of this remarkable paper in the *Comptes Rendus* failed to be struck with it, not only as regarded the weighty matter thus publicly announced, but also on account of the calm and well-founded conviction which the author manifested in the truth of his bold conclusions, and the definite manner in which he gives the challenge to practical astronomers to verify or disprove them. * * * *

"So ardent a conviction in a manner compelled the proof which the geometer claimed, and M. Galle, whose intelligence and zeal are well known, pointed his telescope to the sky the very evening that M. Leverrier's letter reached him. Fortunately provided with a newly published star-map, by Bremicker, of that region of the heavens, which was not at that time diffused generally amongst European observatories, he detected that same night (the 23d Sept. 1846,) a star-like body of the eighth magnitude, not noted in the star-chart, therefore a wandering body, having a manifest disc from 2½″ to 3″ in diameter, and distant only *fifty-four minutes of a degree* from the predicted place.

"It will be remarked that the discovery in question was anticipated and completed in France and Germany alone; England had no direct participation. We must now, however, state briefly what occurred there of a similar character, at the same time, and even earlier.

"Mr John Couch Adams, when a student at St John's College, Cambridge, in 1841, formed the design of detecting the position of a perturbing planet which should account for the anomalous motions of Uranus. He made a preliminary essay on the problem in 1843, assuming the distance of the suspected body from the sun to be double that of Uranus. I learn from good authority that he obtained a place for the unseen planet not very different from that which he finally adopted. Early in 1844 he obtained from Greenwich the valuable series of places of Uranus, which were afterwards in like manner applied for by M. Leverrier. In September 1845, he communicated to Professor Challis the elements of the new planet's orbit (neglecting the inclination) and an ephemeris of its geocentric place.

* * * *

"Mr Adams, in communicating his results (at a later time) to the Astronomical Society, with characteristic modesty says:—'I mention these dates merely to show that my results were arrived at independently, and previously to the publication of M. Leverrier, and not with the intention of interfering with his just claims to the honours of the discovery, for there is no doubt that his researches were first published to the world, and led to the actual discovery of the planet by Dr Galle.'

"And such is no doubt the fact. The priority of Mr Adams in the mathematical investigation is as certain as that the researches of M. Leverrier alone produced the discovery of Neptune." (Arts. 127-140.)

We may add in the words of another writer—"Had there been hope and confidence Leverrier and Adams must have changed places. . . . . Though the basis was sound there was not sufficient faith."

These extracts will prepare the reader for the information that large portions of the work are of interest to the unscientific: indeed, all will find lessons of the highest value in these biographical sketches. An instructive example is contained in Lagrange's directions for the study of mathematics. "I *never studied*," says he, "*more than one book at a time*; if good, I read it to the end. I did not perplex myself with difficulties, but returned to them twenty times, if necessary. I considered reading large treatises of pure analysis quite useless. We ought to devote our time and labour chiefly to the applications. I *always read with my pen in my hand*, developing the calculations, and exercising myself with the questions." (Art 84, note). We have taken the liberty of transposing some of the italics in this passage, and have endeavoured to attach them to the remarks most worthy of attention. We must be allowed to take exception to one sentence of the above extract. Lagrange says—"We ought to devote our time and labour chiefly to the applications." This is not very consistent with his own practice, for he was eminently successful in the invention and improvement of *methods* in analysis, and appears to have devoted immense labour and much time in perfecting those methods, which he gave to the world in *large treatises*. Nor does it quite square with what the author of the Dissertation makes known to us in the following passage: "he himself (Lagrange) is stated to have preferred, amongst all his papers, one in the Turin Memoirs of 1784 on the Integral Calculus." It should always be borne in mind that every development of human thought has its value. Those discoveries which appear to be most widely separated may have affinities to be afterwards exhibited. Different minds are constituted to derive enjoyment from, and to advance the progress of, different elements of knowledge,—one revelling in the abstraction which traces to its conclusions the assumption, as an axiom, of a known impossibility, or developing the wonderful and real consequences of arguing on the supposed intersections of lines which never can meet; another reconciling with the Newtonian theory some irregularities in the motion of Venus; a third tracking the windings of ice-streams, and determining their laws of motion. The results, perhaps, are in themselves of no higher importance to the human race than the fall of an apple or the hues of the rainbow. As exponents of mere matter and force we could dispense with nine-tenths of our science: as an exponent of mind every tittle is valuable.

The author undoubtedly holds mere ingenuity rather cheap,—and we are disposed to agree with him; though he perhaps strains his position a little when he declares (as we understand the passage), that to make contrivances in which the result depends rather upon laws of geometry than of physics hardly entitles the inventor to be ranked amongst men of genius (Art. 35). The distinction here drawn does not appear to be philosophical, though the standard set up may happen to be correct. The measure of an invention or a discovery ought surely to be sought in the number, diversity, and complexity of the elements of thought required; and this being done, the conclusions arrived at will probably be the same as those which the author's standard will give. Thus the separate condenser of Watt will be placed far above his parallel motion; the reflecting quadrant of Hooke and Hadley above the joint of the former; and further, we presume, the condenser will be placed above the nautical quadrant,—but of this we are not quite sure.

Our limits allow us to refer to only one more topic; and that we are obliged to hurry over. This topic is polarization "Malus had already, in the end of 1808, announced a property of light which, if not absolutely new, was entirely so with reference to the circumstances in which it was produced. The polarization of light was in reality discovered by Huygens previous to 1680. He had observed that the two rays into which common light is divided in passing through Iceland spar have a singular diversity of character, which Newton afterwards described as an opposite polarity. * * A definite notion of such a distinction may be formed by imagining a musical string vibrating at one time in a vertical, at another in a horizontal plane. If we could possibly imagine light to consist of vibrations of this description, the two rays of Iceland spar might be conceived, the one to vibrate in a plane passing through the axis of the crystal, the other in a plane perpendicular to that. Such light might truly be said to have acquired the property of *having sides.* In the language of Newton, it is *polarized.*

The discovery of Malus consisted in showing that light may acquire properties identical with those of either ray yielded by refraction through Iceland spar, by the very simple process of simple reflection at a particular angle from any transparent body. Thus, for a surface of water, he found this angle to be 52° 45′ with the perpendicular, and for glass 54° 35′." (Art. 479.) It was subsequently shown by Sir David Brewster that the tangent of the angle is always equal to the refractive index of the substance. "Sir David Brewster's genius was first called forth by the announcement of Malus's great discovery, in 1808, of the polarization of light by reflection. * * * From this time (1813) Sir David Brewster became a regular contributor to the London Philosophical Transactions, which, as well as those of Edinburgh, contain a series of elaborate experimental investigations due to him, which have hardly been surpassed. * * * To him are due

"I. The laws of polarization by reflection and refraction, and other quantitative laws of phenomena.

"II. The discovery of the polarizing structure induced by heat and pressure.

"III. The discovery of crystals with two axes of double refraction, &c.

"IV. The laws of metallic reflection.

"V. Experiments on the absorption of light." (Arts. 521-524.)

Here we must close our extracts. We have time to mention only the lucid exposition of the beautiful theory of Young and Fresnel, of the discovery of circular polarization by the latter, and of that of depolarization by Malus and Arago.

These investigations have succeeded in rendering light, which, in the days of Newton, was hardly comprehended at all, now the most familiarly understood of the elements of nature. But is there no analogy in these respects between heat and light? That luminous heat should exhibit many of the properties of light it was natural to expect: but does the same apply to non-luminous heat? The brilliant and convincing discoveries of Melloni and Forbes leave no doubt about the matter. We subjoin a few extracts from the Report on Radiant Heat presented by Professor Powell to the British Association in 1840.

"Professor Forbes took up the inquiry in November 1834.

"(1.) He proved distinctly the stoppage of a considerable proportion of heat, when the tourmalines were crossed—with brass heated below luminosity.

"(2.) In the third section of the same memoir (Edin. Trans. vol. xii.) he details his researches on the polarization of heat by refraction and reflection.

"(3.) In the fourth section, the author enters on the modifications which polarized heat undergoes by the intervention of crystallized plates between the polarizing and analyzing plates of the apparatus."

On the 1st of February 1836 Professor Forbes announced to the Royal Society of Edinburgh that he had that day succeeded in establishing the *circular polarziation* of heat—even when unaccompanied by light—by direct experiment. This was shortly followed up by the establishment of elliptic polarization. Thus the analogy between heat and light was shown to be complete.

We shall conclude these remarks in Professor Powell's words:

"The sole and undisputed credit of first unequivocally establishing the grand facts of the *polarization of heat*, even from non-luminous sources, by transmission through mica, through tourmaline, and by reflection, together with the peculiar and invaluable property of mica split by sudden heating (a fact holding a parallel rank with that of the diathermancy of rock salt); *depolarization* of heat; its consequent double refraction and interference; its *circular* and *elliptic polarization;* its length of wave, and the production of that wave by transverse vibrations; the confirmation of the circular polarization by the rock-salt rhomb, and the peculiar effects of metallic reflection; these constitute the unquestionable claims of Professor Forbes."

We hope that, as soon as justice to the subscribers to the Encyclopædia shall permit, the Dissertation will be republished in an octavo form; and we feel sure it will find a lasting place amongst the standard scientific works of the present age.

Elements of Chemistry, Theoretical and Practical. By WILLIAM ALLEN MILLER, M.D., F.R.S., &c., Professor of Chemistry in King's College, London.

PART I. *Chemical Physics*, 1855.
PART II. *Inorganic Chemistry*, 1856.
PART III. *Organic Chemistry*, 1857.

In our early student days, the date of which we shall not stop to define, the text-books in use, though they might in some cases be called *Manuals*, were never Hand-books, but rather Arm-books, which had to be squeezed firmly between elbow and side, when carried to and from lodgings and class-rooms. These unhandy volumes were also costly, at least as measured by the depth of a student's purse, for none of them could be procured for less than a guinea, and many cost more. By-and-by, all at once, publishers seemed to discover that "a great book is a great evil," and fell to producing compact volumes within the grasp of the most boyish hand, and costing only about half the sum which was charged for the ponderous tomes of the earlier era. The change was welcomed by all, except, perhaps, the authors and proprietors of the supplanted big books. Teachers felt free to require the poorest students to provide themselves with text-books. Students no longer hunted the book-stalls for cheap ancient editions of some Megabiblon which, in its last issue, differed as much from its first development as a tiger-moth does from a hairy caterpillar. The lecturer, if he missed in the new Finger-book, such ample expositions of favourite topics as filled pages of the old Arm-books, felt that he would have reason to congratulate himself if his pupils knew thoroughly the contents of the smallest of the smaller volumes. The pupil, if he thought there was room for still further omission and condensation, acknowledged, nevertheless, after counting the pages, that in the course of a session he might master them all. So far, unusual contentment for a season prevailed.

Meanwhile, however, as fast as the text-books were growing smaller, the sciences of which they treated were growing larger. Physiology would not cease expanding because Mr A. must raise the price of his Hand-book if he added another sheet to it; nor would Chemistry stand still because Mr B. had stereotyped his last edition. What was to be done in these circumstances? To bring out text-books on the same science, of different kinds, and, therefore, of different sizes and prices, so as to suit different classes of students. Our publishers have done this to the full. If text-books are wanting on any subject which interests a considerable number of readers, it is through defect of authors, not of publishers. The work before us is a happy compromise between such highly-condensed treatises on Chemistry as that of Professor Fownes, and such would-be exhaustive Thesauri as Gmelin's misnamed many-volumed *Hand*-book. Both of these are excellent in their way; the former amply sufficient for the ordinary wants of the student of medicine, for whom it is chiefly intended; the latter a storehouse of reference for men of all professions who have an interest in Chemistry. But Fownes is too brief, and Gmelin too diffuse, besides being too unwieldy and unmanageable, to suit a great and increasing class of students, who seek to acquire a large, though not an exhaustive, acquaintance with the science of which the works in question treat. To them Professor Miller's three volumes will be most acceptable. He is Professor in a College where, besides students of medicine, students of law, of theology, of agriculture, of engineering, and of the military art, attend lectures together. The first-named may be the most numerous, but are not more zealous chemical students than many of the non-medical pupils, who, moreover, have generally more time to devote to the study of chemistry. The author has thus had experience of a diversified class of students, and has written for each section of them. His work is in reality three works in as many volumes, each so independent of the others that it may be consulted as a separate treatise. The first volume, that on Chemical Physics, is the most remarkable; we have no rival work, indeed, in the language. It discusses chemical affinity, weight, measure, molecular force, elasticity, cohesion, adhesion, crystallization, light, heat, electricity, and magnetism. Those subjects, no doubt, are considered in treatises on Natural Philosophy, and as departments of physics have monographs of great value devoted to each of them; but we know no single work which discusses them as they are discussed here, and it is of great importance to students of chemistry, to have in their hands a discussion of physics from the chemist's point of view.

The second volume is devoted to the range of subjects included under Inorganic Chemistry: the third embraces the immense and difficult subject of Organic Chemistry, and furnishes a truly admirable exposition of its vast and intricate details.

It would not be more foolish to show a brick as the sample of a palace, than to quote sentences from Professor Miller's elaborate work as indices of its excellence. But as microscopic observers have certain *test*-objects by which they try the powers of new microscopes, so there are certain subjects which afford tests of the expository skill of chemists and physicists. Let the reader, for example, try Professor Miller on the Laws of Combination, the Classification of Crystals, the Polarization of Light, Electrolysis, Actinism, the Constitution of Salts, the Metallurgy of Iron, the Assay of Silver, Organic Analysis, the Alcohols and their derivatives, the Organic Bases, Homologous Series, the Nutrition of Animals, and the Notation and Nomenclature of Gerhardt. In addition, let him, after the fashion of the *Sortes Virgilianæ*, take several dips at random between the leaves, and read whatever pages thus open to view. He will come, we believe, to as favourable a conclusion regarding the merits of Professor Miller's work by this process, as we have arrived at by steady travelling from title-page to finis in each volume. Three qualities have specially attracted us, as characterising Professor Miller's expositions:—judicial sagacity and impartiality in stating and comparing conflicting doctrines or arguments; undeviating lucidity in describing phenomena or discussing laws; and a literary grace which makes his book very pleasant reading. The first of those qualities gives his work that eclectic character which should be found in every comprehensive text-book. The second is the merit, without which all other merits are meritless, in a treatise for learners. The third is not indispensable, as much profitable study of unattractive German and English authors has satisfied us, and we suppose all men. But there is no reason why French scientific treatises should be the only graceful ones, as our author practically illustrates. He has wisely judged that the intrinsic difficulties of his text are sufficiently great, without adding to them the adventitious darkness of an involved syntax and an obscure style, and without one line of "fine" writing, has made his book most pleasant, as well as most profitable in perusal.

PROCEEDINGS OF SOCIETIES.

Royal Society of Edinburgh.

Monday, 1*st December* 1856.—The Right Rev. Bishop Terrot, Vice-President, in the Chair. The following Communications were read:—

1. *Opening Address.* By Bishop Terrot.

2. *On the Minute Structure of the Involuntary Muscular Tissue.* By Joseph Lister, Esq., F.R.C.S. Eng. and Edin. Communicated by Dr Christison.

In this paper the author describes the discovery made in 1847 by Professor Kölliker, that involuntary muscular fibre is capable of being resolved into nucleated elements, supposed to be of the nature of elongated cells, and hence termed "contractile" or "muscular fibre-cells." He then notices a paper by Professor Ellis of University College, London, in which that distinguished anatomist expresses his belief that "the fibres are long, slender, rounded cords of uniform width," and that the nuclei "appear to belong to the sheath of the fibre." The author then proceeds to describe the involuntary muscular tissue as it presents itself in two situations where he has recently examined it, namely, the minute arteries of the frog's foot and the small intestine of the pig. He finds that in these organs the involuntary muscular tissue is composed of slightly flattened, elongated elements, with tapering extremities, each provided at its central and thickest part with a single cylindrical nucleus imbedded in its substance. Professor Kölliker's account of the tissue is thus completely confirmed in these two instances.

It further appears, from what has been seen in the pig's intestine, that the muscular elements are, on the one hand, capable of an extraordinary degree of extension, and, on the other hand, are endowed with a marvellous faculty of contraction, by which they may be reduced from the condition of very long fibres to that of almost globular masses. In the extended state they have a soft, delicate, and usually homogeneous aspect, which becomes altered during contraction by the supervention of highly refracting transverse ribs, which grow thicker and more approximated as the process advances. Meanwhile the "rod-shaped" nucleus appears to be pinched up by the contracting fibre, till it assumes a slightly oval form, with the longer diameter transversely placed.

The author further remarks, that these properties of the constituent elements of involuntary muscular fibre explain in a very beautiful manner the extraordinary range of contractility which characterizes the hollow viscera.

Monday, 15th December 1856.—Professor CHRISTISON, V.P., in the Chair. The following Communications were read:—

1. *On the Ovum and Young Fish of the Salmonidæ.* By WILLIAM AYRTON, Esq. Communicated by Professor ALLMAN.
2. *Notice of the Vendace of Derwentwater, Cumberland, in a Letter addressed to Sir William Jardine, Bart.* By JOHN DAVY, M.D. (See Number of this Journal for April 1857, p. 347.)
3. *On the Races of the Western Coasts of Africa.* By Colonel LUKE SMYTH O'CONNOR, C.B., Governor of the Gambia. Communicated by Professor KELLAND.

Monday, 19th January 1857.—The Right Rev. Bishop TERROT, V.P., in the Chair. The following Cummunications were read:—

1. *On the Application of the Theory of Probabilities to the question of the Combination of Testimonies.* By Professor BOOLE. Communicated by Bishop TERROT.
2. *On New Species of Marine Diatomaceæ from the Firth of Clyde and Loch Fine.* By Professor GREGORY. Illustrated by numerous drawings, and by enlarged figures, all drawn by Dr GREVILLE.
3. *Short Verbal Notice of a simple and direct method of Computing the Logarithm of a Number.* By EDWARD SANG, Esq.

Monday, 2d February 1857.—The Right Rev. Bishop TERROT, V.P., in the Chair. The following Communications were read:—

1. *On the Urinary Secretion of Fishes, with some remarks on this secretion in other classes of animals.* By JOHN DAVY, M.D., F.R.S., London and Edinburgh.

The urinary secretion of fishes, the author believes, has hitherto received so little attention owing to certain difficulties attending its investigation. He brings forward the few and imperfect observations he has made, with the hope of inducing others more favourably situated to prosecute the inquiry.

The fishes he has examined in quest of their urinary secretion have been fifteen; of those with a urinary bladder he found a fluid only in three, the Perch, Ling, and Ray; and in those without this organ, only in two, in their ureters—those of the Pike and Turbot.

His experiments to ascertain the composition of the secretion were attended mostly with negative results. In one instance, that of the Pike, he detected lithic acid; in some others there were indications of the presence of urea in the fluid urine.

The conclusions he ventures to draw are, that the secretion is small in quantity, mostly liquid, and that urea or some other analogous nitrogenous compound is its principal ingredient.

2. *On the Reproductive Economy of Moths and Bees; being an Account of the Results of Von. Siebold's Recent Researches in Parthenogenesis.* By Professor Goodsir.

(See Number of this Journal for April, p. 319.)

3. *On the Principles of the Stereoscope; and on a new mode of exhibiting Stereoscopic Pictures.* By Dr W. Macdonald.

Monday, 16th February 1857.—Dr Christison, V.P., in the Chair.

The following Communications were read:—

1. *On the Crania of the Kaffirs and Hottentots, and the Physical and Moral Characteristics of these Races.* By Dr Black, F.G.S.

2. *On a Roche Moutonnée on the summit of the range of hills separating Loch Fyne and Loch Awe.* In a letter from the Duke of Argyll to Professor Forbes.

What appears to me to be the peculiarity of the "Roche Moutonnée" I am now about to describe, is its position, forcing us to seek for its explanation in causes with which the physical geography of the country can have had comparatively little to do. On going to one of the highest points on the ridge separating Loch Fyne and Loch Awe (probably about 1800 feet above the level of the sea), during last autumn, I was surprised to observe close to the summit so remarkable an example of a well-rounded surface of rock as to attract my attention from a considerable distance. The direction from which the abrading force has acted is about N.N.E. It has passed over a lower shoulder in its way—lower by about 100 feet; but the effect is strongest upon the rocks of the main peak itself, and especially upon one or two prominent faces within twenty or thirty feet of the summit. Above this it may be observed sloping off, as it were, with diminished force, over successive ledges towards the top, until it passes close behind the very highest point, leaving that point itself apparently untouched. I need hardly say, that in this case glacier action is impossible. Even if this hill had itself been the seat of the glacier, it could only have been snow so near the summit. There is one explanation which immediately suggests itself to the mind, and, however difficult it may be to realize the conditions which it involves, it is the only one which it seems to me to be possible to suggest. It is that this peak, when subject to that grinding force, was a rocky islet just appearing above the surface of a glacial sea, and that floating icebergs, drifting from the north-eastward, were constantly grounding upon its sides.

3. *On M. J. Nicklès' claim to be the Discoverer of Fluorine in the Blood.* By George Wilson, M.D., F.R.S.E., Regius Professor of Technology in the University of Edinburgh.

A communication was made to the French Academy, at its meeting on the 3d of November 1856, by M. J. Nicklès, entitled "Presence du Fluor dans le Sang." From the tenor of M. Nicklès' remarks, it would seem that he was not aware that the existence of fluorine in the blood was announced by me in 1846, and specially demonstrated in 1850; nor is he acquainted with the researches which others besides myself have made in this country and in America, into the distribution of fluorine throughout the different kingdoms of nature.

My researches have been chiefly published in the "Transactions" of this Society, and of the British Association, but have been brought in part before the Chemical Society of London. They are known in Germany, Denmark, Sweden, and America, and have been referred to by many authors in this country. It is reasonable, accordingly, to infer that some knowledge of them has reached Paris; and it might have been supposed that they had not altogether escaped the notice of M. Nicklès, whose name appears on the title-page of the *Journal de Pharmacie et de Chimie*, as editing the department of that work entitled "Une revue des Travaux Chimiques publiés à l'Etranger."

I bring no charge, however, against M. Nicklès. In these days of multiplied monographs it would be unjust to blame any man for ignorance of a single series of special researches. Nevertheless, seeing that this author's name appears on the title-page of the *Journal de Pharmacie* side by side with those of our Vice-President Dr Christison, as its Edinburgh Correspondent, and of Dr Redwood, the Secretary of the Cavendish Society, as its London Correspondent, the countrymen of M. Nicklès may think themselves entitled to quote the legal maxim, "de non apparentibus et de non existentibus eadem ratio," and to infer that what of reputed English science is not known to him, does not exist to be known. Whilst, therefore, I wish M. Nicklès all success in extending our knowledge of the organismal distribution of fluorine, I ask from him, now that he is made aware of the fact, acknowledgment of my priority in reference to the discovery which he specially claims, and of the other discoveries which the papers referred to announce.

Monday, 2d March 1857.—The Right Rev. Bishop TERROT, V.P., in the Chair. The following Communications were read:—

1. *On the Functions of the Spinal Cord.* By Professor HUGHES BENNETT.

The object of Dr Bennett's communication was to unite two separate kinds of research, which of late had been directed towards advancing our knowledge of the structure and functions of the spinal cord. From these it would, he thought, appear, that the views considered to be so firmly established by the genius and labours of Charles Bell required great modification. Dr Bennett then gave a sketch of these views, and of the present opinions of physiologists regarding the functions of the spinal cord. He indicated certain facts which had long been recognised as difficult of explanation in accordance with them. He then described the results of several experiments by M. Brown-Séquard on the columns of the cord in living animals, which he himself (Dr B.) had witnessed, and which satisfied him that, on the posterior columns being cut across, increase of sensibility in the inferior extremities was the consequence, instead of paralysis. He also described the discoveries recently made in the structure of the spinal cord, by Budge, Kölliker, Lockhart Clarke, Stilling, Remack, Wagner, Van der Kolk, Schiling, Kupffner, and especially by Owsjannikow. He pointed out how the structural discoveries threw light on the experimental ones, and from the whole inquiry drew the following conclusions:—

1. Although the anterior and posterior roots of the spinal nerves may still be considered motor and sensitive, we can no longer apply these terms to the anterior and posterior columns of the cord.

2. The fibres in these columns do not convey impressions directly and

continuously to the brain as hitherto supposed, but enter the gray matter, and operate through the ganglionic cells of that matter.

3. That all so-called reflex movements are carried on by a definite system of conducting fibres and ganglionic cells, passing through the grey matter; in other words, they are *diastaltic* and not reflex.

4. That the particular fibres and cells which are necessary to spinal diastaltic acts have yet to be discovered; so that a new field of inquiry is opened up to the physiological histologist.

2. *On the Delta of the Irrawaddy.* By T. Login, C.E., Pegu. Communicated by William Swan, Esq.

3. *Notice of a Collection of Maps.* By A. K. Johnston, Esq.

Monday, 16*th March* 1857.—Dr Christison, V.P., in the Chair. The following Communications were read:—

1. *Notice respecting Father Secchi's Statical Barometer, and on the Origin of the Cathetometer.* By Professor Forbes.

(See Number of this Journal for April, p. 316.)

2. *History of an Anencephalic Child.* By Dr Simpson.

3. *On certain Laws observed in the Mutual Action of Sulphuric Acid and Water.* By Balfour Stewart, Esq. Communicated by Dr G. Wilson.

The object of this paper was to show that where sulphuric acid combines with water, distinct reference is made to certain definite compounds or hydrates of sulphuric acid.

The combination of these two liquids is attended with contraction of volume; that is, the volume occupied by the compound is less than the sum of the volumes occupied by its ingredients when uncombined. By means of a simple formula (assuming 1·8485 to be the specific gravity of strong liquid sulphuric acid), we may find what ought to be the specific gravities of the different strengths in Dr Ure's table, were no contraction to take place. By this table we may find the actual specific gravities of such mixtures; and dividing the actual or observed specific gravity by the calculated specific gravity, and deducting unity from the quotient, we have the proportional condensation. The proportional condensation is greatest for strength 73 of Dr Ure's table, which is the strength of a hydrate composed of one atom of liquid acid and two atoms of water.

The author's experiments confirmed a maximum point corresponding to the hydrate $HO, SO_3 + 15\,HO$, and showed a minimum point corresponding to the hydrate $HO, SO_3 + 6\,HO$. In conclusion, the author's results were briefly stated thus:—

1. The points of elevation, depression, or peculiarity in the curve of condensation, denote definite compounds, whatever be the standard strength used.

2. The use of varying the standard is simply to render such points more prominent, or, in other words, to convert a point of peculiarity into one of elevation or depression, as the case may be.

Monday, 6*th April* 1857.—Dr Christison, V.P., in the Chair. The following Communications were read:—

1. *On the Structure of Pedicellina.* By Professor Allman.

The author maintained that the genus Pedicellina, notwithstanding the circular arrangement of its tentacula, does not properly belong to the infundibulate Polyzoa at all, but is in reality hippocrepian, of which type, however, it presents a remarkable modification. The intestine at first sight appears to terminate within the margin of an orbicular lophophore, and, consequently, within the circle of tentacula, and thus to present a striking exception to the admitted plan of the Polyzoa. It was shown, however, that the anomaly which thus seems to exist was only apparent, for the lophophore, when carefully examined, is found to be constructed on the hippocrepian type, with the tentacula confined to the outer or convex margin, and the arms of the crescent united at their extremities so as to enclose a space, around which the tentacula will then be arranged in an uninterrupted circle, and within which the intestine opens, its termination being thus quite normal, and properly external to the lophophore.

As in the ordinary hippocrepian Polyzoa, so also here the mouth is furnished with an epistome, which, however, is less complete than in the others, and not provided with special muscles; and it is moreover highly probable that the calyx, which constitutes a universal feature in the ordinary hippocrepian genera, enters here into the composition of the peculiar cup which surrounds the base of the tentacula, and which the author believes has its homology in a permanently inverted portion of the endocyst, united externally to the uninverted endocyst, and internally to the calyx and tentacula.

2. *On a Case of Lateral Refraction in the Island of Teneriffe.* By Professor C. PIAZZI SMYTH.

In his astronomical visit to Teneriffe last summer, the author was instructed to inquire into the lateral oscillation of stars, as seen by Baron Von Humboldt in his ascent of the mountain. During a month's residence on the place of the alleged observation no approach to anything of the sort was ever noticed, although a powerful equatorial, with a twelve-foot telescope, and high magnifying powers, was employed to detect any irregularity in the motions of the stars. The author, concluded, therefore, that the anomalous movements described by Humboldt could not have been produced by any general or cosmical action of the atmosphere, or of light or heat, which astronomers were bound to consider.

3. *On Insect Vision and Blind Insects.* By ANDREW MURRAY, Esq.

(This Paper appears in the present Number of this Journal.)

4. *On the mode in which Light acts on the Ultimate Nervous Structures of the Eye, and on the relations between Simple and Compound Eyes.* By Professor GOODSIR.

Since the publication, in 1826, of Joh. Müller's *Vergleichende Physiologie des Gesichtssinnes*, physiologists have admitted three fundamental forms of the organ of vision. 1*st*, The eye-spot, organized for the mere perception of light. 2*d*, The compound eye, in which the picture on the nervous surface is a mosaic. 3*d*, The simple eye, in which the retinal picture is continuous. The difference between the simple and compound eye, as explained by Müller, and since generally admitted, consists in this, that the formation of the picture in the simple eye is the result of the convergence of all the pencils diverging from the visible points of the object on corresponding points of the retina, by means of the lenticular structures of the organ; while, in the compound eye, the picture is formed by the stopping off, by means of the constituent crystalline columns of the eye, all rays except those which pass in or near the axes of the columns. The extent of surface of any object, and the number of separate parts of such surface, represented on the nervous structure of a compound eye, will vary, therefore, in terms of the distance of the object, the curvature of the superficial ocular surface, the corresponding inclination of the crystalline columns to one another, the size of their individual transverse sections, and their lengths. The continuous retinal picture in the simple eye is psychically interpreted as a continuous image. If, therefore, the possessor of a compound eye perceives a continuous image of an object, it must be the result of a more complex psychical operation, in virtue of which, the separate portions of the ocular mosaic picture are psychically combined, and interpreted as a continuous whole.

The successive researches of Treviranus, Gottsche, Hannover, Pacini, H. Müller, and Kölliker, have determined the existence and general structure of close-set rods or columns, which extend between the inner and outer surfaces of the retina, in the midst of the nervous and vascular textures of that membrane. The outer extremities of these rods present a crystalline columnar aspect, and constitute, collectively, the external layer of the retina, usually termed Jacob's membrane. The ultimate filaments of the optic nerve, after being connected in a plexiform arrangement in the ganglionic layer of the retina, terminate each independently in the more perfect portion of the retinal field, by passing into, or becoming continuous with, the inner end or side of a rod. Kölliker considers these rods as nervous structures, that is, as terminal portions of the nerve-filaments themselves, and holds that they constitute the parts of the nervous structure of the eye on which objective light primarily acts.

Having myself carefully examined the structures to which I have now alluded, I have been able to verify the more important anatomical details, as described by their discoverers, and agree with Kölliker in considering the rods as the primary optic apparatus. I cannot, however, coincide with this distinguished observer in holding these rods as modified nerve filaments. I hold them to be special structures appended to the extremities of the ultimate nerve filaments, and referable to the same category as the Pacinian bodies, touch-corpuscles, rods of Corti, &c.; and, moreover, so far am I from coinciding with Kölliker in his speculations as to the part of the rod on which the objective light acts, that I have found myself compelled, not only from the consideration of the structures themselves, but also from the development of the eye itself, and the arrangements of the compound eye, to conceive the rays of light as acting upon the retina, not as they impinge upon it, or pass through it from before, but as they pass backward again out of the eye after reflection from the choroid.

The general aspect of the rods, and more especially of those portions termed Müllerian filaments, where they collectively amalgamate in the limitary membrane of the retina, indicate, as I believe will be generally admitted, that they consist of a modification of connective tissue, enveloping and supporting the extremities of the ultimate nerve filaments in such a manner as to form special structures, which, from their functions, may be termed *photæsthetic bodies.*

That special structures are required for the initiation of action in the filaments of the optic nerve by objective light, appears to be established by the facts, that the nervous filaments of the retina, and the cut extremities of these filaments on the stump of the optic nerve, are not affected by it, although irritation of the same filaments by electrical or other means produces subjective luminous phenomena. Subjective sounds may be produced by various modes of irritation; but actual sonant vibrations can only excite the acoustic filaments through the medium of the rods of Corti, or the corresponding terminal structures in the vestibule. Corresponding terminal structures are in like manner appended to the tactile, olfactory, and gustatory nerves, apparently for a similar purpose, to provide the necessary conditions of the initial excitement of the nervous current by those secondary properties of external bodies to which the organs of touch, taste, and smell, are related.

When the attention of anatomists was directed, a few years ago, to the structure and physiological signification of the columns of the retina by the observations of H. Müller and Kölliker, I became satisfied that those structures are not, as the latter asserted, nervous structures, properly so called, but special structures, of the same nature as the Pacinian bodies and the tactile corpuscles. I stated and explained my opinion of the nature of these bodies in a lecture on the retina delivered and reported in 1854. But I had generalized these relations of nervous filaments to special terminal exciting structures, still further, in the zoological lectures which I delivered in 1853, for my late distinguished colleague and preceptor Professor Jameson. I also expounded it at considerable length in my course of lectures last winter (1855–6). I shall now state the doctrine in general terms, not only because it is necessary for the elucidation of the distinctive characters of the simple and compound forms of eye; but also because I am anxious to put on record, by submitting it to this society, a generalization which appears to me of primary importance in the general physiology of the nervous system. I assume, as established, the doctrine of Du Bois Raymond, that a nerve filament is capable of propagating the nervous current equally well in both directions; and that the physical and physiological characters of this current differ in no respect, are in fact identical in the so-called motor and in the so-called sensory filaments, whether special or common. I also assume as established that the specific manner in which a centripetal nerve current is converted at the central extremity of the filament, that is to say, is physiologically reflected into motor filaments, or, psychically interpreted as sensation, depends upon the physiological or psychical endowments of the different portions of the nervous centre with which the filaments are connected. These two positions being assumed, then, I hold that, although the ultimate nervous filament may have its functional current (that is the common nervous current) excited or initiated by electrical or other physical or chemical agencies, yet this current can only be initiated or excited, for the special functional purposes for which each nervous filament is provided in the economy, by the structure or tissue with which such filament is connected peripherally. If so, then, not only are the individual filaments of the nerves of special sense provided with current-exciting structures at their peripheral extremities, by means of which alone the objects to which they are related can initiate the nerve current; but also centripetal nerve filaments of whatever kind, are provided, in their connection with the textures from which they proceed, with arrangements, by means of which alone their functional currents can be initiated.

From this point of view every particular structure in the organism from which nervous filaments proceed to the nervous centre, may be considered with reference to the nervous system, as a peripheral nervous organ,—that is, an organ capable of exciting or initiating centripetal nerve current; which is physiologically converted, or psychically interpreted at the corresponding central organ, according to the special endowments of that central organ.

After this preliminary statement, I am in a position from which I can explain the mode in which I understand the structure and actions of the rods of the retina in the simple, and the columns in the compound eye.

1. *In the simple eye.*—A ray of light can only impress an ultimate retinal nervous filament under certain conditions. These conditions are, that it should impinge upon the distal extremity of the filament in, or parallel to, the axis of that filament, or within a certain angle to that axis.

All rays impinging on the distal extremity of an ultimate retinal nervous filament under the conditions stated I term *photogenic* rays. Rays impinging upon, or passing through, the filament in any other direction, may be termed *aphotogenic*. The distal portion of the ultimate retinal nervous filament, I distinguish as the *photæsthetic surface*.

In order that the ultimate retinal nervous filament may be subjected to the rays of light under the required conditions of vision, its distal extremity or photæsthetic surface is inclosed in a peculiar structure, consisting of a so-called *rod* or *cone* (which I distinguish as the crystalline column), and its appended Müllerian filament, with its nuclear enlargements. This structure constitutes a specific kind of peripheral nervous organ, which, from its function, I term a *photæsthetic body*.

A photæsthetic body consists of a distal segment, or dioptric portion, elongated, cylindrical, or club-shaped, homogeneous, transparent, and highly refractive, usually termed the rod or cone; and a proximal segment or peduncle, with its nuclear enlargements, into which the ultimate nervous filament passes, and within which it apparently terminates, probably at its outer end.

The entire aspect and arrangement of these photæsthetic bodies, their predominance over the other parts of the retina at the axial spot of the eye, and the direct continuity of their stems with the nerve filaments at that spot, appear to me to indicate not only the nature of their functions, but also the general features of the mode in which it is effected. It appears to me that the rays which act upon the nervous filaments must be such rays as the arrangement permits to pass from behind, forwards in the axes of the photæsthetic bodies. It has now been ascertained, that the quantity of light reflected, and consequently irregularly dispersed within the eye-ball from the choroid, and bacillary layer, &c., is very considerable; and it consequently becomes a very important question, to determine in what manner this reflected and irregularly dispersed light is prevented from affecting the retina. The view which I have already given of the structure and probable mode of action of the photæsthetic bodies affords the basis of a hypothesis which meets all the conditions of the question, and is in full accordance with the comparative anatomy and development of the organ of vision. I cannot interpret the functions of the structure of the retina as now determined, except by assuming that the photæsthetic columns are impressed not by the light as it enters the eye, or as it is more or less irregularly reflected and dispersed in its interior, but only by those rays which, in their passage backwards to the pupil pass along, or nearly in, the axes of the crystalline rods or columns of the photæsthetic bodies, so as to reach the photæsthetic spots under the required conditions. No confusion, therefore, can result from the multitude of convergent and divergent rays which pass through the chamber of the eye, and through the retina. By this means, the numerous rays not necessary for vision, are as it were eliminated from the operation, the eye being blind to them, and affected only by such as are reflected backwards to the pupil along the axes of the crystalline columns.

2. *The Crystalline Columns of the Compound Eye.*—As stated in my lecture on the retina, formerly alluded to, I conceive the crystalline columns in the eye of the insect or crab, to act in the same manner as the retinal rods in the spheroidal or simple eye. That they do so may be held as established by the researches of J. Müller on the laws of vision in the compound eye. Müller even refers to the columnar structure of the retina, as presenting a certain similarity to the structure or arrangement of the compound eye. F. Leidig, in an elaborate memoir published in Müller's Archiv. in 1855, on the structure generally of the Arthropoda, ex-

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amines minutely the structure of the simple and compound eyes, and arrives at the conclusion that the crystalline columns of their compound eyes, as well as the corresponding structures in their so-called simple eyes or ocelli, are of the same nature as the so-called rods and cones, that is, the photæsthetic bodies which I have already described in the retina of the vertebrate eye. But Leidig entirely loses sight of a fact, which, if unexplained, vitiates his conclusion as to the physiological identity of the bodies in question. In the annulose or molluscous eye, whether in its so-called simple or compound form, the crystalline columns are directed, like the tubes of so many telescopes, towards the object, the corresponding nervous filaments passing to them from behind; whereas the crystalline rods of the vertebrate retina are directed away from the object, that is, towards the back of the eye—are in contact, in fact, with the choroid, while their nervous filaments are connected to them in front, that is, between them and the object.

On the other hand, if I am correct in holding that the vertebrate eye is acted upon by those rays only which are reflected from its choroidal surface, I have not only explained physiologically why its retinal columns are reversed, but I am legitimately entitled, as Leidig is not, to consider them as the homologues of the crystalline columns of the annulose and molluscous eye.

But the teleological explanation of the opposite arrangement of the corresponding structures in the vertebrate and invertebrate eye, is, in the present phase of the science, insufficient. The difference must be explained morphologically. This explanation is afforded by the different modes in which the vertebrate and invertebrate, that is, the simple and compound eyes are developed.

In the compound eye the primordial ocular papilla or convexity, which is only slightly protuberant, has its cutaneous or superficial surface immediately converted into the crystalline columnar structure, the individual columns of which are connected with the filaments of the subjacent optic nerve. The columns are all therefore directed to the object.

The primordial cerebro-cutaneous spheroidal protuberance or papilla of the simple refracting or vertebrate eye, is speedily hollowed out in front by the development in or upon it of the lens and vitreous humour, so that from a spheroidal convex surface, the primordial protuberance assumes the form of a cup, with its mouth directed forwards, and its cavity occupied by the refracting media of the organ. This cup-shaped mass is the retina; the crystalline rods are not developed on its concave surface, but on its outer or convex surface, as they exist on the convexity of the compound eye, that is, in the direction of the radii of the sphere, but directed backwards, on account of the nearly spheroidal surface.

In conclusion, I may state what appears to be the physiological superiority of the simple over the compound eye. As the simple eye is acted on by reflected light only, it cannot be disturbed by rays not required for the definition of the image. It is also arranged so as to admit of a much more delicate or minute mosaic representation of the object, from its microscopic and reversed photæsthetic bodies being in contact with the reflecting choroidal surface on which that image is formed. It moreover combines the advantages of the contiguous image, formed by the lenticular structures, and the mosaic image, which results from its crystalline rods.

Monday, 20th April 1857.—Dr Christison, V.P., in the Chair. The following Communications were read:—

1. *On the recently discovered Glacial Phenomena of Arthur's Seat and Salisbury Crags.* By Robert Chambers, Esq.

2. *On a Dynamical Top, for exhibiting the Phenomena of the Motion of a System of Invariable Form about a Fixed Point; with some Suggestions as to the Earth's Motion.* By Professor Clerk Maxwell.

The top is an instrument similar to that exhibited by the author at the meeting of the British Association in 1856. It differs from it in being of smaller size and entirely of brass, except the ends of the axle; and in having six horizontal adjusting screws and three vertical ones, instead of four of each kind.

It consists of a hollow cone, with a heavy ring round the base, and an axle, terminating in a steel point, screwing through the vertex. In the ring are the nine adjusting screws, and on the axle is a heavy bob, which may be fixed at any height.

By means of these adjustments the centre of gravity of the whole is made to coincide with the steel point, and the axle of the top is made one of the principal axes of the *central ellipsoid.*

The whole theory of the spinning of such a system about its centre of gravity depends on the form of Poinsot's ellipsoid corresponding to the particular arrangement of the screws. The top is intended to exhibit those cases in which the three axes of this ellipsoid are nearly equal. In these cases the instantaneous axis is never far from the normal to the invariable plane, which we may call the invariable axis. This axis is fixed in space, but not in the body; for it describes, with respect to the body, a cone of the second order, whose axis is either the greatest or the least of the principal axes of inertia.

To observe the path of the invariable axis in the rapidly revolving body, we must have the means of recognising the part of the body through which it passes at any time. For this purpose a disc of card is placed near the upper end of the axle. The four quadrants of this disc are painted red, yellow, green, and blue, and various other marks are added; so that by observing the colour of the spot which appears the centre of motion, and the diameter of the coloured spot, the position of the invariable axis in the body at any instant may be known, and its path traced out.

This path is a conic section, whose centre is in the principal axis. If that axis be the greatest or least, it is an ellipse with its major axis parallel to the mean axis. If the axle of the top be the mean axis, the path is an hyperbola as projected on the disc.

When the axle is the axis of greatest inertia, the direction of motion in the ellipse is the same as the direction of rotation. When it is the axis of least inertia these directions are opposite. All these results may be deduced from Poinsot's theory, and verified by means of the coloured disc.

The theory of precession may be illustrated by this top in the way pointed out by Mr Elliot, by bringing the centre of gravity to a point a little below or above the point of support.

The theory and experiments with the top suggest the question—Does the earth revolve *accurately* about a principal axis? If not, then a change of the position of the axis will take place, not in space, but with respect to the earth, so that the apparent positions of stars with respect to the pole will remain the same, but the latitude of every place will undergo a periodic variation, whose period is about 325 days. To detect this variation, the observations of Polaris with the Greenwich transit circle for four years have been examined. There appeared some doubtful indications of a variation not exceeding half a second. A more extensive investigation would be required to determine accurately the period, and the epoch of maximum latitude at a given observatory, which must depend on the longitude of the station, as the pole of the "invariable" axis travels round the mean axis from west to east.

3. *On the true Signification of certain Reproductive Phenomena in the Polyzoa.* By Dr Allman.

When the reproductive phenomena of Alcyonella, as manifested both in gemmation and true generation, are viewed in their proper sequence, they will be found to present a series of acts which admit of an obvious comparison with the class of phenomena commonly known as the "alternation of generations."

From the fecundated ovum an embryo is produced in the ordinary way after the segmentation of the vitellus. In this embryo, which presents at first the form of a locomotive ciliated sac, sexual organs are never directly developed, but there are produced within it by a process of *gemmation* the following series of zooids. 1. A polypide, which, like the containing sac, is essentially nonsexual, and which is eminently organised for the functions of digestion. 2. A peculiar bud, at first undistinguishable from the polypide-bud, but which never develops digestive organs, and is soon seen to be filled with proper ova, each with its germinal vesicle and germinal spot. This body may, in accordance with common usage, be called the ovary of the zooid from which it is developed, but since it is produced from this zooid in the manner of a bud, exactly as the polypide is, it may itself be fairly viewed as a unisexual zooid, in which the whole organization becomes subservient to the reproductive function, while all the other functions and their special organs become masked and suppressed by the dominant development of the organization destined for generation. 3. Another unisexual bud developed upon the polypide, endowed with a male function and commonly called the testis, but truly a distinct zooid, with its whole organization rendered subservient, as in the ovary bud, to generation. 4. A nonsexual bud of peculiar form (the statoblast) also developed from the polypide.

The essential features in the reproductive phenomena just enumerated present themselves in an indefinitely repeated series, where the first and last terms of each cycyle consist in a fecundated ovum, and the intermediate terms in a succession of gemmæ.

4. *On the Destructive Distillation of Animal Matters.* Part IV. By Dr Anderson, Glasgow.

5. *Analysis of Specimens of Ancient British, of Red Indian, and of Roman Pottery.* By Murray Thomson.

Ancient British Pottery.

Silica, ...	52·49	51·24	51·86
Alumina, ...	13·29	12·46	12·87
Peroxide of iron, containing phosphates corresponding to 1·01 Phosph. Acid, and also a trace of manganese.	18·19	18·94	18·56
Lime, ...	4·85	5·13	4·99
Magnesia, ...	0·60	1·64	1·12
Soda, ...	3·06	2·97	3·01
Potass, ...	0·55	0·78	0·66
Organic matter, . . .	2·14	2·33	2·23
Water, ...	4·70	4·76	4·73
	99·87	100·25	100·23

Ojibbeway Pottery.

Silica, . . .	42·70	43·60	43·15
Alumina, . . .	22·71	22·12	22·41
Peroxide of iron, . .	10·58	10·03	10·30
Lime, . . .	1·33	1·46	1·39
Magnesia, . .	2·60	2·88	2·74
Organic matter, . .	10·28	10·10	10·01
Water, . . .	9·79	9·99	9·89
	100·19	100·18	100·185

Lustrous Red Roman or Samian Ware.

Silica,	54·78
Peroxide of iron, containing phosphates corresponding to 0·42 Phosph. Acid,	21·43
Alumina,	8·74
Lime,	12·67
Magnesia,	1·33
Water,	1·26
	100·21

6. *Theory of Linear Vibrations.* Part VI. *Alligated Vibrations.* By Edward Sang.

This part of the paper contains an inquiry into the action of a vibrating body upon a linear elastic series, as representative of the action of a sound-emitting substance upon the air.

The general conclusions are these :—That the observed phenomena of sound are inconsistent with the supposition of a perfectly elastic vibratory medium, and that either the viscidity, or some as yet unknown quality of the air, has to do essentially with the production of those phenomena, so that any analysis in the present state of our preparatory knowledge must be futile. And that the undulatory theory of light is altogether conjectural, since far from knowing how one supposed wave would influence another, we do not yet know anything of the manner in which such waves can be formed at all.

Royal Physical Society.

Wednesday, 26th November 1856.—Robert Chambers, Esq., President, in the Chair.

1. *Opening Address.* By Robert Chambers, Esq.
2. *On* Hydractinia Echinate. By T. Strethill Wright, M.D.

(See Number of this Journal for April, p. 298.)

3. *On the Structure and Habits of the Slow Worm* (Anguis fragilis, Linn.). By Daniel R. Rankin, Esq., Carluke. Communicated by Professor Fleming.

(See Number of this Journal for January, p. 102.)

4. *Description of New Insects from Quito. List of Old Calabar Insects.* By Andrew Murray, Esq., W.S.

(See Number of this Journal for April, p. 220.)

Dr John Alex. Smith exhibited the cranium of a red deer (*Cervus elaphus*), which showed an interesting variety in the development of its antlers; the right antler being without branches, and 13 inches in length; and the left 16¾ long with its first branch, or brow antler (as it is commonly termed, from projecting over the brow), 6½ inches long, but in this case rising from the back part of the horn, at about two inches from its base, and projecting backwards. It was believed to be of great age, and the horns may show an accidental variety depending on that cause. The stag was recently shot at the Doune of Rothiemurchus by Lord Alexander Russell, to whose politeness the Society was indebted for its exhibition. Dr Smith also exhibited a rabbit, taken in a trap near Carnwath, in the beginning of this month, and kindly sent to him by Mr John Dickson, gunmaker, Princes Street, from the singularity of the extreme length of the fur on the upper part of its body. The peculiarity was believed to be dependent on the rabbit being a cross with an escaped individual of the long-haired, so-called Russian rabbits, which are frequently kept by rabbit fanciers.

Wednesday, 24th December 1856.—This meeting was adjourned, owing to the death of Mr Hugh Miller on the morning of that day.

Wednesday, 28th January 1857.—W. H. Lowe, M.D., President, in the Chair.

The President opened the business of the meeting with some remarks on the loss which the Society, and science in general, had sustained in the death of Mr Hugh Miller.

1. *Observations in British Zoophytology*:—1. Clava (*three new species*). 2. Eudendrium (*two new species*). *Illustrated by Specimens and Drawings.* By T. Strethill Wright, M.D.

(This Communication is printed in the present Number of this Journal.)

2. *Notice of Dredgings in Lamlash Bay.* By Robert K. Greville, LL.D.

Dr Greville gave a sketch of the results of the dredgings carried on in Lamlash Bay last summer, by the Rev. Dr Miles and himself, as a Committee of the British Association, and stated that they would be published in their Transactions. He laid on the table tabulated lists of marine animals taken in that locality, referring particularly to some of the more interesting species, and believed that locality to be pretty nearly worked out. He mentioned that this last season seemed, from some unknown cause, to have been generally unfavourable to the inquirers in this department of natural history, from the unusual rarity of marine animals. Dr Greville then gave some interesting details of the habits of various marine creatures, including several species of small fishes, as observed by him in a large vivarium in Arran, adding, that he believed in this way we would ultimately be enabled to acquire a very complete knowledge of the habits of many most interesting species.

3. *On the Prehensile Apparatus of* Spio seticornis. By Thomas Strethill Wright, M.D.

(This Communication is printed in the present Number of this Journal.)

4. *Ornithological Notices.* By John Alex. Smith, M.D. (Specimens were exhibited.)

5. *Notes on the British species of* Patella, *from information communicated by Dr Knapp.* By Andrew Murray, Esq., W.S.

The object of this paper was to point out a very marked variety of the *Patella vulgata*, which had been found by Dr Knapp in Guernsey and Jersey. It was principally characterized by its rich yellow or brown-creamy colour inside, its more depressed form, and more prominent ribs, white at the top. A very fine series of species both of this variety and the other British species of Patella was exhibited. Notwithstanding its marked peculiarities, Mr Murray considered it only a variety of *P. vulgata*, and proposed to call it *P. vulgata*, var. *intermedia*.

Wednesday, 25th February 1857.—Professor Balfour, President, in the Chair. The following Communications were read:—

1. *On the genus* Ateuchus (*the Egyptian* Scarabæus), *and its South American representatives, with descriptions of new species of the latter.* (Specimens were exhibited.) By Andrew Murray, Esq. W.S.

Mr Murray commenced by referring to the interest which attached to this group of beetles, from its having been an object of veneration to the ancient Egyptians, and sculptured so frequently on their ancient monuments. He exhibited a series of specimens of these antiques, and pointed out that it was quite easy to distinguish to which species they ought to be referred. Those specimens exhibited all belonged either to *Ateuchus sacer*, or *Ateuchus laticollis*. He detailed several interesting anecdotes connected with their habits, and their wonderful instinct of making, rolling, and burying balls of excrementitious matter, generally containing their eggs. He also explained their geographical distribution, showing that they were confined to the Old World, but possessed representatives in South America (known under the generic name of *Eucranium*), bearing a very close affinity to a South African species (*Pachysoma Æsculapei*). He concluded by describing some new species of these South American beetles, which he had received through the kindness of Dr Stark of Edinburgh, to whom they had been sent from the deserts of Cordova, by Mr Black, a very zealous naturalist (son of our respected member for the city), who is now in Chile.

2. *On the Contemporaneous Geological Age of the "Mountain" and "Burdiehouse" Limestone Beds of the Linlithgowshire Coal-Field.* By Andrew Taylor, Esq.

The object of Mr Taylor's communication was to describe a geological section in the Bathgate Hills—taken from Dechmont Laws to Balbardie House, in which a limestone containing fresh-water fossils, and equivalent to the one worked at Burdiehouse, gradually merged into another limestone containing marine fossils, which is usually recognised as the lowest bed of the carboniferous series.

3. (1.) *Notice of the occurrence of* Apophyllite *at Ratho.* (Specimens were exhibited.) (2.) *Sections of* Lepidostrobi *were exhibited.* By Alexander Bryson, Esq.

4. *Notice of a Discovery of* Diatomaceæ *in the Marl of Waitnean and Brakegoe, near Wick, Caithness-shire.* By Charles W. Peach, Esq., Wick.

5. (1.) *Notice of the Horn of a Reindeer* (Cervus tarandus, *Linn.*), *found in Dumbartonshire.* By John Alexander Smith, M.D.

At the close of last session, I exhibited to the Society several shells and a deer's horn, which had been recently found during the excavation of a cutting on the Forth and Clyde Junction Railway. My friend, James Macfarlane of Balwill, Esq., knowing the district well, was kind enough to draw up at my request a "memorandum," formerly read to the Society; and I have since been furnished with some additional information. The locality in which the horn, shells, and fragments now on the table were found, immediately adjoining the hamlet of Croftamie, situated in the county of Dumbarton, parish of Kilmaronock, in the basin of the river Endrick (which flows into Loch Lomond), and at a distance of nearly a mile from that river, and about four miles from the nearest part of Loch Lomond. The superincumbent mass consisted first of the vegetable mould, then of a stiff till about twelve feet thick, containing a large quantity of stones, some of a round form, apparently water-worn, others angular, and many of them of a great size. Under the till was a bed of blue clay about seven feet thick, and at the lower part of this bed, and close upon the sandstone rock, the horn was dug out of the clay at the depth of about eighteen feet; and at a few yards' distance the shells were found in a similar position, lying at a depth of about twenty-one feet from the surface, the ground cut through rising a little higher at that part. As nearly as can be calculated from the railway plans and sections, these remains lay from 100 to 103 feet above the level of the sea. The shells consisted of the following species:—*Cyprina islandica*, *Astarte elliptica*, and *A. compressa*, *Fusus antiquus*, *Littorina littorea*, and the shelly base of a species of *Balanus*. They are all marine species, at present inhabiting the neighbouring seas. I previously noticed their relation to beds of marine shells found near the shores of Loch Lomond, pointing to a total change in the character of the district, when Loch Lomond existed as an arm of the sea. But into this subject I do not again enter, my communication now referring to the deer's horn (which I exhibit), the other object of interest found in the railway cutting. The horn was supposed at first to be simply that of a red deer, which, from being water-rolled, had become smooth. The Society, however, would remember I stated that I was inclined to consider it as belonging to the *reindeer*. It is a fragment of the horn of the right side, and has been broken off obliquely, just below the slightly prominent burr,—it shows the origin of the brow antler close to the burr, and at about two inches' distance that of a second antler, or tine, at which part the horn is much compressed in its character, the origin of the antler being quite flattened; beyond this we have the smooth and rounded beam, becoming again compressed and angular at the upper part, where it is broken across. The horn is small, measuring 11½ inches in length, and one inch in breadth midway between the origins of the antlers. These characters all agree closely with the horn of the reindeer. Since the meeting of the Society, at which it was previously exhibited, I have been anxiously seeking for small-sized horns of the reindeer to compare with it, and at last was fortunate enough to get the horns of a young or female reindeer, of the American variety. I ex-

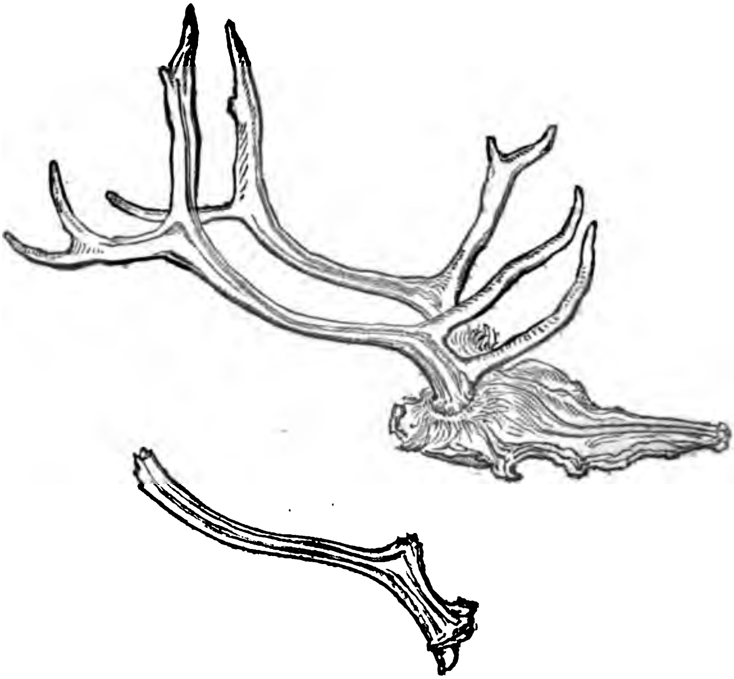

exhibit these horns, and the Society will at once see the very close resemblance between them. (I am indebted to T. B. Johnston, Esq., for kindly favouring me with the annexed careful drawing, which shows the relation between this broken horn, and the perfect horns of the recent reindeer.) And, to set this matter completely at rest, I then forwarded the horn to our great authority in fossil remains, Professor Richard Owen of London, who favoured me with the following reply:—"It gives me pleasure to inform you that the portion of antler from the basin of the Endrick, which you sent for my inspection, is of a young or female reindeer of the existing species, and if, as is most probable, a female, of the large variety called 'Carabou' by the Hudson's Bay trappers." Professor Owen, in his valuable "History of British Fossil Mammals," refers to two instances of the cranium or horns of the reindeer being found in England. The only instance described, as far as I am aware, of its occurrence in Scotland, is that recorded by Dr Scouler of Glasgow, in the "Edinburgh Philosophical Journal" of 1852, p. 135. This consisted of a portion of the distinctive palmated brow-antler. I have much pleasure, therefore, in recording another instance of the remains of this animal—now so exclusively a native of the more northern parts of Europe and America—being found in Scotland.

(2.) *Notes on the Wood Sandpiper* (Totanus glareola, Temm.) *Shot in Mid-Lothian.* By John Alex. Smith, M.D.

Wednesday, 25th March 1857.—Andrew Murray, Esq., W. S., President, in the Chair. The following Communications were read:—

1. *On the Geology of the Neighbourhood of Elie.* By the Rev. Walter Wood, A.M., Elie.

The paper was confined to a view of the relations between the trap and the sedimentary rocks, as displayed on the shore. The prevailing trap rock has been commonly called trap tuffa, but is known by the local name of "Leck." It is uniformly stratified, and never occurs superimposed upon the Coal Measures. The alternate patches of the two rocks are separated by faults filled up by wacke and fragments of sandstone. Hence it would appear that the "Leck" had at one time uniformly covered the sedimentary rocks; that the mass had been broken up by faults; and then by denudation the whole of the tuffa had been removed, except such portions as had sunk to a lower level.

2. *Analysis of Three Waters from Palestine, viz.: The Water of Marah; the Hot Springs of Tiberias; the Baths of Pharaoh.* By Allen Dalzell, M.D.

The waters in question had been sent to the College Laboratory by Dr Stewart of Leghorn, by whom they were brought from the Holy Land. The first water Dr Dalzell wished to mention was from a spot little visited by travellers, on the western side of the Sinai peninsula, and was believed by Dr Stewart to be the "Marah" of Scripture. As taken from its source it was found by that gentleman to be charged with sulphuretted hydrogen. The Marah water, as he received it, had a specific gravity at 60° of 1008·5, and contained 1400 grains of solid matter in the imperial gallon. The following showed the nature and proportions of the constituent salts:—

Chloride of sodium	40·725
Sulphate of lime	12·520
Sulphate of magnesia	40·716
Chloride of magnesium	6·040
	100·000

The second water was that of the Baths of Tiberias, at its source a sulphureous thermal, and of too high a temperature to permit of the hand being held in it. It had not been previously analysed with care. Dr Dalzell found its specific gravity at 60° to be 1022·5, and the solid residue of a gallon to be 2821 grains, or about twice as much as Marah yields; nearly 80 per cent. of its saline matter was common salt, as the following table showed:—

Chloride of sodium	76·85
Sulphate of lime	11·01
Sulphate of magnesia	12·14
	100·000

The third water was also sulphureous and thermal. Its original heat must have been great, as, from some notes accompanying the bottles, it appeared that a thermometer graduated to 120° Fahrenheit, instantly burst on being immersed in it. At 60° he found its specific gravity to be not far from that of the Marah well, viz., 1007·9, and the solid residue from a gallon 1211 grains. Like the Dead Sea, it contained much magnesia, and, as in that water, so here, the amount of sulphate of lime was smaller than in either of the preceding. Its analysis showed, of

Chloride of sodium	73·215
Sulphate of lime	6·720
Sulphate of magnesia	20·065
	100·000

Dr Dalzell concluded by stating, that in a portion of Dead Sea water taken from the northern end, the specific gravity of which was 1210 at 60°, he found 17,402 grains per gallon of solid matter, 56·12 of which was chloride of magnesium, 29·62 chloride of sodium, 11·25 chloride of calcium, a little more that 2 per cent. chloride potassium, 0·43 sulphate of lime, and 0·28 consisted of the bromides of magnesium and potassium.

3. (1.) *A few Fossils from Vancouver's Island were exhibited.* (2.) *Notice of a Tetraodon (believed to be new) from Old Calabar.* (The specimens were exhibited.) By Andrew Murray, Esq.

Mr Andrew Murray exhibited a few fossils from Vancouver's Island. They belonged to the Lower Chalk, and consisted of a species of ammonites and baculites (*B. ovatus*, Say.), *Diceras* (*Caprotina*, D'Orb.), *Venus*, *Unicardium*, and *Psammobica.*

Mr Murray also exhibited a species of *Tetraodon* received from Old Calabar, through the kindness of Mr Wylie. It did not correspond with any of the species described by Lacepede, and was probably new. Instead of being armed with great spines, it was nearly smooth, except on the belly, where it was covered by a number of small prickles. It was dark brown above, and pale beneath, and had a row of six deep red spots along its sides. Mr Murray named it provisionally *T. pustulatus.*

4. (1.) *Observations in British Zoophytology.* (2.) *Description of two new* Protozoa. By Thomas Strethill Wright, M.D.

1. *Observations in British Zoophytology—Trichydra pudica.*—The author had given this title to a very minute Zoophyte, found by him on shells and stones from the Firth of Forth. He described it as follows:—Corallum membranous creeping; cells, sessile, cylindrical, about one-tenth of the length of the extended polyps. Polyps, about one-eighth of an inch in length; shaped like a fresh-water Hydra; very attenuated and transparent; with from four to twelve long waving tentacles. Buccal cavity small, conical, dense, silvery white by reflected light. Polyps very sensitive; bending down the head and tentacles when exposed to strong

light, like a flower drooping on its stalk. He classed this zoophyte at present amongst the Corynidæ of Johnston, on account of the progressive development of the tentacles, which increased in number with the increasing age of the polyp.

Laomedea acuminata.—A description of this zoophyte had been published in December last by its discoverer, Mr Alder. Dr Wright had possessed specimens since May last. In August, and again during the present month, pedicled and very large capsules had been developed from the foot of the annulated polyp stalks, from each of which capsules a single medusoid (of great size when compared with the polyp) was liberated. This medusoid was mitre-shaped, and distinguished by the bright emerald-green reflected colour of its sub-umbrella. It had four tentacles, two long and two rudimentary, all ringed as to their bulbs with dark blue. The auditory sacs were eight in number, placed one on each side of the tentacles. No eye-specks or reproductive apparatus existed. The length was from 1-10th to 1-8th of an inch. Great numbers of these medusoids had been produced, several of which had been examined by members of the Society present, and others.

2. *On two new* Protozoa.—Both these species were marine, and belonged to the family *Vorticellina.* The author had designated the first, which was attached to deep-water shells, *Lagotia* (the hare-eared animalcule.) It inhabited a dark green tube, resembling in shape a soda-water bottle laid on one side, with the neck bent upwards, and prolonged into a trumpet-shaped mouth. The body of the animalcule was long and cylindrical, and was surmounted by a rotatory organ, which, in one aspect, resembled the head and ears of a hare, in another, that of a narrow or compressed horse-shoe, bordered with a fringe of moving teeth. The whole body was clothed with an undulating fleece of cilia. The colour of the body was hyaline, transparent green, or atro-purpureous.

Vaginicola valvata resembled *V. crystallina* of fresh water, but it was distinguished from the latter animalcule, especially by the presence of an oval horny valve, situated about half-way down its tube, and which closed down in an inclined position over the animal when the latter was contracted. The valve was developed within, and covered by a fleshy plate, which was attached by one edge, and continuous with a pellicle which lined the whole of the inside of the tube. The tube and the horny plate of the valve were not hinged or connected together otherwise than by their fleshy coverings. In dead and empty tubes the valve was absent.

Wednesday, 22*d April* 1857.—W. H. Lowe, M.D., in the Chair.
The following Communications were read:—

1. *Notes on Scottish Lepidoptera in* 1855-56. (Numerous specimens were exhibited.) By R. F. Logan, Esq.

In this communication Mr Logan added twenty-four species to the list of *Heterocera* occurring near Edinburgh, many of them discovered by the industry and energy of the Messrs Wilson.

2. *On the Chalk Flints of the Forth.* By Professor Fleming.

The author stated, that having visited the Black Rocks, Leith, on the 28th ult., at a low ebb-tide, after strong easterly winds, he was surprised to find a large heap of *Chalk Flints*, from which the covering of sand had been removed by ripple action. Similar flints had been observed by Mr Christie of Hawkhill, in a field to the eastward of the house, and the author had detected a single nodule in the brick-clay of Kinghorn. Having previously observed a bed of flints, with angular masses of *chalk*, in the middle of a deposit of brick-clay, on the Aberdeenshire coast, he refuted the usual notion that the flints occasionally found on the shores of the

Forth were the remains of *ship-ballast*, and gave it as his opinion that they were the wreck of cretaceous strata, which formerly existed in the neighbouring sea, and were a prolongation of the Denmark beds.

3. *Observations in British Zoophytology.* By THOMAS STRETHILL WRIGHT, M.D.

The principal object of this notice was to elucidate some points in the anatomy and physiology of *Tubularia indivisa*, which have escaped detection or presented difficulties to the numerous authors who have written on this zoophyte.

4. *Notice of two Fossils found in a bed of Shale below St Anthony's Chapel, Arthur's Seat.* By JAMES M'BAIN, M.D., R.N.

This bed rests upon Amygdaloidal trap-tuff, and is covered by another bed of columnar basalt, on which the chapel is built. It has been long known to the geological explorers of Arthur's Seat that this shaly bed contained fossil organisms, apparently of a vegetable character, to which the general term "fucoid" has been applied. In June 1854, on visiting this spot, and chipping a portion of the thin laminated clay, I found a small tooth imbedded in it, which apparently belonged to the genus Holoptychius—most probably to the *Hol. Hibbertii.* The other fossil organism evidently belongs to the vegetable kingdom. Several specimens have been found, but they all appear to be mere fragments. The nearest resemblance to these specimens which I have seen figured in plates is that of *Bechera charæformis*, accompanying the Memoir of Mr James Prestwick, "On the Geology of the Coalfield of Coalbrookdale," from the Transactions of the Geological Society of London, vol. v. for 1840.

Botanical Society of Edinburgh.

Thursday, 13*th November* 1856.—Professor FLEMING, V.P., in the Chair.

The following Communications were read:—

1. *Notice of Diatomaceæ, Desmideæ, &c., collected in Ceylon.* By Dr KELAART.

2. *Notice of the Occurrence of* Crambe maritima *near Edinburgh.* By Mr JOHN W. BROWN.

3. *On the Stellate Hairs of* Aralia papyrifera. By Professor BALFOUR.

4. *Notice of the Results of three days Botanizing in the neighbourhood of Totworth Court, Gloucestershire.* By Professor BALFOUR.

5. *Notice of the Stoppage of a Water Pipe by the Roots of a Tree.* By JOHN DUNCAN, Esq. Communicated by Professor BALFOUR.

In a field at Burnhead there is a large reservoir, and from this water is conveyed in a leaden pipe for some distance to a well, the water of which is drawn up by a pump. In the course of last autumn no water could be drawn from the well, and on examination the bottom of it was found to be dry, and filled with an enormous matting of roots. These roots had also penetrated into the leaden pipe, and filled it up completely, so as to prevent the water from flowing. On cutting through the pipe and pulling out the roots, which were very firmly impacted, the water flowed in abundance. The roots were traced by Mr Duncan to a sycamore tree (*Acer Pseudo-platanus*) growing near the well.

6. *On a Method of Preserving Plants in their Natural Form, and with the Colour of the Flowers.* By Messrs REVEIL and BERJOT. Communicated by Professor BALFOUR.

7. *On* Callitriche hamulata *of Kutzing, found near Jardine Hall.* By F. Townsend, Esq. Communicated by Sir Wm. Jardine.

The plant was gathered in a ditch communicating with the river Annan, close to Jardine Hall. Mr Babington has decided that it is the plant described in his Manual as *C. pedunculata*, var. *sessilis*. The important character in *C. hamulata* is the falciform bracts. These fall off early, and were not noticed by Mr B. in ordinary wild specimens. He has, however, of late observed them in cultivated specimens of his *C. pedunculata*, var. *sessilis*. Mr B. considers *C. hamulata* as the type of the species, and *C. pedunculata* to be a variety.

8. *On Garden Plants found in Waste Ground near Falmouth.* In a Letter from Mr W. P. Cocks to Professor Balfour.

Thursday, 11*th December* 1856.—Professor Balfour, V.P., in the Chair. The following Communications were read:—

1. *Description of a Method of Preserving Plants of their Natural Form and Colour.* By Thomas R. Marshall, Esq.

The plant to be operated on should be placed in a box, in such a manner as to preserve the natural disposition of its parts. The fine sawdust (perfectly dry) of box, or other hard wood, is then to be carefully sprinkled over it, taking care not to shift the position of the leaves. Every part of the plant must be completely covered with the dust. Several plants may be dried in one box—avoiding contact, however. The plants to be preserved ought to be quite fresh when put into the box; if they be lax, place the stems in water till the vessels again distend and recover their natural firmness. About a fortnight in the dust is sufficient to dry the plants in summer (in a natural heat); succulent plants require longer. To assist in freeing the plants from the sawdust, the box may be made with a wire grating and sliding bottom; slightly shake the plant to free it from the dust; what still adheres may be brushed off with a soft hair pencil.

2. *On the Species of Pine called in Moffat "Dr Walker's Pouch Fir."* By Professor Fleming.

3. *Notes on some new Species of Marine Diatomaceæ from the Firth of Clyde.* By Professor Gregory.

4. *Notice of Hepaticæ, found near Aberfeldy.* By John Lowe, Esq.

Thursday, 8*th January* 1857.—Professor Balfour, V.P., in the Chair. The following Communications were read:—

1. *On the Production of Ergot on Rye.* By Kenneth Corbet, Esq., Beauly. Communicated by Dr Douglas Maclagan.

The author noticed the occurrence of ergot on rye in the neighbourhood of Beauly, and stated that he found that this native ergot was more certain in its medical action than that imported from the Continent. He expressed his opinion that the production of ergot was connected with an abortive condition of the pollen, whose application to the stigma did not result in the development of an embryo. He found that by cutting off the stamens in the early stage the ovary became liable to an attack of ergot.

2. *On a Monstrosity in the Fruit of* Silene inflata, *with some Remarks on Placentation.* By A. Dickson, Esq.

Mr Dickson exhibited a specimen with partitions in the ovary. He considered that the specimen he produced went to support the view of central placentation in all cases, as suggested by Schleiden.

3. *Notice of Plantain Flour.* By Murray Thomson, Esq., late Assistant in the Laboratory of the Industrial Museum of Scotland. Communicated by Professor George Wilson.

4. *Analyses of Three Australian Wines.* By Murray Thomson, Esq. Communicated by Professor George Wilson.

5. *On the Injurious Effects of* Uroceras gigas *on Fir Trees.* By the A. Thomson, Esq., Banchory.

The author stated that last summer his forester had observed a Scotch fir tree, about thirty-five years old, die very suddenly. The tree was cut down and taken to the saw-mill. During the preparation of the wood a large fly was observed in a burrow in the wood. Subsequently another fly, a grub, and the remains of a cocoon were seen. The insect was examined, and found to be the *Uroceras gigas.* It has been rarely noticed in Scotland. It appears, however, that in Germany it often causes great destruction in the forests. If there be any appearance of the insect spreading in this country, it would be well to draw further attention to it, so that every tree showing symptoms of it might be destroyed. This is the only remedy found of use in Germany, where they say hundreds of acres have been sacrificed on one estate after another, with the view of checking its progress. Specimens of the timber and of the insect were exhibited, along with a piece of foreign timber containing a grub of a similar nature.

6. *On the Occurrence of the Seeds of Bearded Darnel in Inferior Samples of Wheat.* By George S. Lawson, Esq.

7. *Notes on* Pinus cephalonica, *and other Coniferæ, at Craigo House, Montrose.* By Mr P. S. Robertson, Golden Acres.

Thursday, 12th February 1857.—Professor Balfour, V.P., in the Chair.

The following Communications were read:—

1. *Notes of a Botanical Excursion to Switzerland and other parts of the Continent during last summer.* By Mr R. M. Stark.

2. *List of Plants observed in the Neighbourhood of Blackford, Perthshire.* By Mr Alex. Buchan.

3. *Notice of the Plants of Mount Olympus.* By Dr John Kirk. *With an Account of the Ascent of the Mountain, and Observations on the Country near Broussa.* By Dr David Christison.

Thursday, 12th March 1857. The following Communications were read:—

1. *Notice of a Botanical Trip to Moffat and the Mountains in its vicinity, in July* 1856. By Professor Balfour.

2. *On an Abnormal Development of the Nectary in Ranunculus.* By A. J. Macfarlan, Esq.

3. *Notice of* Chara syncarpa *new to Scotland.* By W. Nichol, Esq.

4. *Remarks on Boucherie's Method of Preserving Timber.* By Professor Balfour.

5. *Recent Botanical Intelligence.* By Professor Balfour.

Thursday, 9th April 1857.—Professor Balfour, V.P., in the Chair.

Mr I. Anderson, S.S.C., exhibited a plant of a hybrid Rhododendron between *R. atrovirens* and *R. formosum,* which was stated to be quite hardy, being chiefly remarkable for its large blossoms, which were triple the size of the seed-bearer (*R. atrovirens*).

The following Communications were read:—

1. *On the Effects of a Solution of Bicarbonate of Ammonia, in promoting Vegetation.* By C. J. Burnett, Esq.

2. *Does Magnetism Influence Vegetation?* By H. F. Baxter, Esq. Communicated by Professor Balfour.

The author states that the results of his inquiry into this subject are negative, that is, no positive evidence has been obtained to show that magnetism either does or does not influence vegetation. After noticing the opinions of Becquerel, Dutrochet, and Wartmann, the author says:—"As it may be considered a law in vegetable physiology that all plants have a tendency, during the germination of their seeds, to develop in two diametrically opposite directions (the root and the stem), the question arose—might not this direction be influenced or counteracted by submitting the seeds whilst germinating to the influence of magnetic force." Accordingly, a series of experiments were undertaken by the author, which are classed under two principal heads: 1*st*, Those in which the line of magnetic force was directed *perpendicularly* to the plants; and 2*d*, In which the line of force was directed *transversely* to the plant. The author gave details of the experiments, which were varied and multiplied. No definite conclusions, however, could be drawn from them relative to the effect of magnetism.

3. *On* Lycium mediterraneum. By Dr Thomas Anderson, H.E.I.C.S. Communicated by Professor Balfour.

Dr Anderson states that, after careful and repeated examination of specimens of *L. Edgeworthii*, Dunal, he is convinced that Dunal's so-called species is only a variety of *L. mediterraneum* (*L. europæum*, Linn.). Dr Anderson then gives revised characters for the species, and concludes with observations on the effects of the climate of India in modifying the habits of plants, and giving rise to numerous varieties.

4. *On the Applications of Botany to Ornamental Art.* By Mr George Lawson, F.R.P.S.

Mr Lawson exhibited a panel carved by Mr B. Reeve, representing in its side ornaments *Polypodium alpestre* and *Polystichum Lonchitis*. In connection with this study from nature, he called attention to the inexhaustible source of novelty in design which the vegetable kingdom presents, and which he hoped would be made more fully available than hitherto.

5. *Remarks on Dust Showers, with Notice of a Shower of Mud which occurred at Corfu on 21st March* 1857. By Mr George Lawson, F.R.P.S.

Mr Lawson remarked:—The attention of botanists has at different times been attracted to showers of various kinds, most of which have been more or less dependent upon, or connected with, vegetable phenomena. The red snow of the Arctic Regions, which has been known since the days of Aristotle, owes to botany its proper explanation as not a product of the clouds at all, the appearance being due to a minute algæ that vegetates on the surface of the snow. Showers of pollen are familiar to all travellers who have penetrated far among the coniferous forests of North America. In this case also, although the pollen forms immense clouds of dust, and is often conveyed to considerable distances, becoming in its course intermixed with foreign matter, still it can scarcely be referred to as a "shower" in the meteorological sense of the term, the plants to which it owes its origin being present, and connecting the phenomenon more or less closely with what occurs to a certain extent in all flowering plants. Of a different character are the showers of dust or sand described by Humboldt and by Ehrenberg as occurring near the Cape de Verde Islands, at a distance of several hundred miles from the African coast, where the decks of ships navigating the ocean became covered with it.

In this dust many minute organisms, especially diatomaceæ, have been found. Mr Lawson then noticed a shower of mud that occurred in the Island of Corfu about a fortnight ago, the particulars of which are contained in the following letter from Mr Mackenzie:—

"A singular meteorological phenomenon occurred here on Saturday, 21st March. The day was squally and showery; those light showers brought down a great quantity of mud; the next morning I found the cauliflowers covered over with this fine dust. On examining the surrounding fields I found the trees and every other object covered in the same manner. As some writers have asserted, and others have denied, that the same phenomenon is of frequent occurrence in Malta, I send you a few leaves with the precipitate still upon them, which will, I think, put the question to rest for ever. The second question is more difficult to solve; namely, is this native dust, or has it been imported by aerial currents from Africa? From the state of the weather during the three previous days, I am led to favour the latter opinion, and forward an extract from my meteorological register.

"Dr Calla tells me that he remembers something of the same kind when a boy, about forty years ago.

Date.	Thermometer.		Barometer.			Wind.
	Max.	Min.	8 A.M.	3 P.M.	8 P.M.	
March 18, . .	60	52	30·11	30·09	30·09	W.S.W.*
March 19, . .	59	50	30·10	30·10	30·09	S.E.†
March 20, . .	60	51	30·05	29·99	29·94	S.E.‡
March 21, . .	59	51	29·81	29·80	29·81	S.E.§

* Overcast and calm. † Densely overcast.

‡ Gloomy and threatening—high wind in the night.

§ Squally and showery throughout the day and night, and with yesterday's rain there fell a great quantity of mud of a dirty red colour; the plants throughout the island are covered with this fine precipitate. This phenomenon is said to be of frequent occurrence in Malta.

"Corfu, 25th March 1857."

Observations of the barometer, &c., as registered by Mr Cockburn at the Royal Society's Rooms, were laid before the meeting for comparison.

6. *Registering of the Flowering of certain Spring Plants in the Royal Botanic Garden, Edinburgh, from 12th March to 15th April 1857, as compared with the five previous years.* By Mr JAMES M'NAB.

Thursday, 14th May 1857.—Professor BALFOUR, V.P., in the Chair. The following Communications were read:—

1. *Notice of Two Cases of Poisoning with the Seeds of* Thevetia nereifolia. Communicated, with remarks, by Dr DOUGLAS MACLAGAN.

The history of these cases, which occurred in India, was furnished by Dr John Balfour, H.E.I.C.S. The symptoms were narcotico-irritant, the irritant character predominating, and the somnolence and other cerebral phenomena being, in Dr Maclagan's opinion, probably as much those of exhaustion as of true narcotism. There was vomiting of a peculiar character. The letter narrating the cases contained portions of the plant sufficient to enable Dr Maclagan to identify it as *Thevetia nereifolia*, Juss. (*Cerbera Thevetia*, L.) This plant, now naturalized in India, appears to have been introduced probably from South America. Dr Maclagan had compared the *Thevetia nereifolia* of the Indian collections with the *Cerbera peruviana* of Mathew's catalogue, and had no doubt of the identity of these plants, which are given as synonymous in Decandolle's Prodromus.

2. *Account of the Insect which infests the Seeds of* Picea nobilis. By Andrew Murray, Esq., F.R.S.E.

This beautiful silver fir (the *Picea nobilis*) was first introduced into this country from the north-west of America, by Douglas in 1831. In what state the seed sent by him arrived here I have been unable to ascertain with perfect accuracy. The fact that plants of an age corresponding to that period are exceedingly rare would seem to indicate either that the quantities imported by Douglas were less than we have reason to suppose, or that from some cause or other they had not been productive. On the other hand, Professor Lindley informs me that he never heard that Douglas's importations were in any way attacked by insects, and that the Horticultural Society of London raised what he sent home without anything of the kind being observed; and I am informed by my friend Mr M'Nab, that the cones sent by Douglas, which have been preserved as specimens, show every symptom of having been perfectly sound. No second importation of seed to this country was made in any quantity till Jeffrey sent home some packages in 1852. These proved all bad, and apparently had suffered from the ravages of an insect. Mr Beardsley and my brother next sent home a quantity in 1854, along with the seeds of other pine trees, some of which proved new. In an account of their expedition, and of the novelties discovered by them, which I had then the honour of reading to this Society, I noticed the fact that, in almost every cone of *P. nobilis*, the seeds were being eaten by a small caterpillar. My brother had found these caterpillars in the green as well as in the mature cone, their eggs evidently having been deposited in the kernel while the cone was yet soft, and easily penetrated. One or two subsequent importations of seed (the last a very large one, made last autumn on behalf of the Oregon Botanical Association), proved to be also to a greater or less extent infested by an insect. From these importations I have bred the insect, and find that it belongs to the genus *Megastigmus*, one of the *Chalcidites*, a family of the so-called Ichneumon flies.

3. *On the supposed influence of the Moon on Vegetation in Peru.* By Archibald Smith, M.D.

4. *On some of the leading plants of the lowest zone in Teneriffe.* By Professor C. Piazzi Smyth.

The author described the manner and characteristics of growth of the chief plants as met with advancing from the sea-coast inland, and found both the indigenous and the cultivated plants to exhibit a poverty of growth as compared with many other lands in the same latitude, or 28.° The cause of this, he thought, was owing to the special predominance of the Trade-wind throughout the Archipelago of the Canaries during the whole of the summer season, and to the want of rain, and the low temperature which the said wind produces, both primarily and secondarily. In the details of the native plants, the author treated at length on the *Dracæna Draco*, as being, *par excellence*, the characteristic plant of the lowest zone of Teneriffe, and having in one of its specimens, the Great Dragon Tree of Orotava, acquired more fame than any other individual specimen of the vegetable kingdom; and he concluded with an exhibition of the forms of the Dragon tree at different ages, and other Teneriffe plants, optically projected on a screen 8 feet square, from photographs of which the original negatives had been prepared by himself last summer, and positive copies had been made with much skill and success by M. Orange in the course of the winter.

Professor Balfour read the following analysis of specimens of volcanic sand from the Andes, sent by Professor Jameson, of Quito, and analysed by Mr Bloxam, assistant in the Industrial Museum:—By qualitative analysis it appears to be composed of silicic acid, peroxide of iron, alumina, carbonate of lime, and small quantities of potassa and soda. A stream of carbonic acid passed through water, in which the sand was suspended, dissolved out much carbonate of lime. The sand contains small quantities of the protoxide of iron. Its quantitative composition is as under:—

Silica,	68·00
Peroxide of iron, and alumina,	21·20
Carbonate of lime,	9·10
Magnesia and alkalies,	1·70
	100·00

SCIENTIFIC INTELLIGENCE.

ZOOLOGY.

Distribution of American Turtles.—At a recent meeting of the Boston Society of Natural History, Professor Agassiz stated that he had been engaged in an investigation into the Geographical distribution of the Turtles of this country. For a correct determination of specific differences, it became necessary to collect specimens from all parts of the country as extensively as possible, and he thinks he has obtained specimens of nearly all the species existing in North America, and that he has been able to trace their geographical distribution very completely. The results to which he has arrived show this fact, that several species which have been supposed identical throughout their whole geographical range, are now demonstrated to be really distinct; whilst others which have been described as different species, the young alone in some instances having served for description, have been found to be one and the same. He particularly called attention to the danger of describing species solely on theoretical grounds as different, because they inhabit different parts of the world, or as identical from general resemblances. Dumeril and Bibron in their work on Herpetology, and others, have attempted to identify marine turtles of different waters without sufficient authority. Professor Agassiz had taken particular pains to inquire about the Sphagis or Leather-backed Turtle, which is found from the West Indies, northward, and which has been taken at Cape Cod. This animal has been said to inhabit the Mediterranean, but after a thorough investigation he can find only seven or eight instances recorded of its having been found there. The museum at Salem furnishes an opportunity for distinguishing between the Imbricata of the West Indies and that of the Indian Ocean, which have been considered the same. Holbrook describes the Tryonix of Georgia as existing in the Northern Lakes, and he traces the exact course by which it could ascend along the coast and up the Mississippi river to the lakes. But Professor Agassiz finds that there are four different species in the United States, three of which are to be included in the one species of Holbrook, and that each species has its own limited locality.

The Chelidra, or Snapping Turtles, have the most extensive geographical range of any of the Chelonians. The snapping turtle of Massachusetts is found in South Carolina, Alabama, Louisiana, Missouri, and even at the head waters of the Osage.

Of the family of Emydæ, *E. Blandingii* is the true type. The swimming Emydæ are either southern or western species; there are none in new England except those which have only a limited power of swimming.

Emys oregonensis was described by Nuttall as existing west of the Rocky Mountains. Professor Agassiz doubts its existence west of the

Rocky Mountains, because no turtles have been found in those high regions lying between the Rocky Mountains and the Sierra Nevada. Upon the Alleghanies turtles have been found at a height of eleven hundred feet only, and there are no indications of their existence above this height. He has had two specimens from localities east of the Rocky Mountains, one of which was brought from Minnesota. He thinks Mr Nuttall's specimen must have come from this side of the mountains.

Professor Agassiz concluded that there is no general law regulating the distribution of the chelonians of North America. They are distributed through four grand divisions of the country, a north-eastern, a southern, and a Pacific range. The facts of their geographical distribution are now well established, but the reasons are by no means evident at present. The probability is, that different individuals of the same species of animals are adapted by peculiar organizations to different climacteric influences, and that there is no general law of distribution for which physical agents can account.—(*Wells's Annual of Scientific Discovery for* 1857.)

Resistance of Insects to Influence of Cold.—Dr Wyman, at a recent meeting of the Boston Society of Natural History, stated that he had examined chrysalids of the common mud wasp, a species of Pelopæus, and found that they were not frozen during the coldest weather. On the morning of February 7th, when the thermometer had been − 18° Fahr., and had risen to about − 8° Fahr., they were still unfrozen, and when removed from their pupa cases, made obvious muscular motions. The pupa preserved its usual transparency and flexibility; when crushed upon the surface upon which they rested, the fluids of the body instantly became opaque and were congealed. The question naturally presents itself, as to the source of the heat which enables them to preserve their temperature when exposed to so low a degree of cold. The non-conductors by which they are surrounded consist of a casting of mud, and within this a tightly woven, but thin, silky cocoon. It would seem that so small a body, exposed to cold so intense, must have an internal source of heat. He had also examined the eggs of the moth of the canker-worm, and found their contents unfrozen.—(*Wells's Annual.*)

BOTANY.

Senegal Gum, according to Soubeiran, is of two kinds; the *Hard Gum from Galam*, and the *Friable Gum or Sadrabeida.*

The *Hard Gum, from Galam*, or from below the river, consists of exudation from the bark of two closely allied species of *Acacia*, the *A. Verek* (Flor. Seneg. Tentam.), and the *A. Neboued* (id.). As their origin is different, so these substances are not exactly alike. The gum of *Acacia Verek* is white, wrinkled, and dull externally, glassy within, "in the shape of tears, often vermicular and twisted, but generally ovoid or spherical, two inches, often less, in diameter, with a slight and agreeable flavour, accompanied by a little acidity, which is scarcely observable but by those who habitually use it." It is perfectly soluble in water, and affords a much clearer and thinner mucilage than that of Gum Arabic: it reddens litmus-paper, though less than gum does. The *Acacia Verek* is a tree of middling stature, 18–24 feet high at most, much ramified, the branches twisted and armed with numerous sharp-pointed thorns: the wood is hard, the bark grey, and from the latter the gummy liquid naturally exudes, which becomes hard in from twenty to thirty days. It is more abundantly diffused, and forms thicker forests on the right bank of the river than the left, growing in Senegal, all round Saint Louis, in Oualo and Ghioloff, and in the country of the Moors, to the confines of the Sahara Desert, as far even as the shifting sands which extend to Cape Verd. In all these localities it is associated with the *Acacia Ne-*

boued (the *Mimosa Neb-neb*, and Red Gum-tree of Adanson), which chiefly differs from *A. Verek* by its redder gum, which is almost always formed in round balls, from half-an-inch to an inch in diameter, transparent, and slightly bitter-tasted. The *Neboued Gum*, which dissolves perfectly in its own weight of water, also forms a much thicker mucilage than the *Verek*, and colours litmus-paper very little.

The *Senegal Gum* is chiefly collected by the nomade Arabs of the Southern Sahara, who call themselves Bedaouins (wanderers), but whom the Colonists name Moors. A few quintals of the substance are very occasionally brought by the Negroes of Oualo and Ghioloff, who inhabit the left bank of the river: the first are a most apathetic race, and the latter, who offer a remarkably fine sort of gum, are much debarred from entering the market by the Moors, who are jealous of their neighbours, and who seek to monopolize the trade in gum.

There are several distinct tribes of Moors, who devote themselves to the collecting of gum, and each claims and explores its own peculiar oasis or forest of gum-trees. The best gum is obtained from the Oasis of Sahel, where hardly any tree grows but *Acacia Verek;* the tribe called Trarzas owns this forest. An inferior article is produced in the Oasis of El-hiebar, which consists more of *Acacia Neboued* than *A. Verek;* it is in the possession of a very numerous family of Marabouts. Again, a still less valuable gum, called *Gonakie*, comes from the Oasis of El-Fatak; while scattered bands of Arabs collect small quantities of gums, of greater or less value, in remote spots, far from the river.

The *Ghioloff Gum*, which comes in very small quantities, is infinitely the finest, the purest, and clearest, with a bright surface, a glassy, almost crystallized fracture, and in large bits. The Moors are so averse to its exportation, that it is only obtainable as a sort of contraband article.

The *Bondou Gum* is very often mixed with the *Galam Gum*, is difficult to be distinguished by sight alone, and baffles the eye of experienced traders, but is recognized by its bitter flavour. It is the produce of an *Acacia*, near *A. albida*.

The *Gonaké* or *Gonaté Gum* (so called from the tree which yields it, and to which the natives give that name) is collected abundantly in the Oasis of El-Fatak. It is redder than the other gums; but the facility with which it is dried and pulverized affords an easy mode of adding it to the better sorts and adulterating them; and the Moors thus habitually increase the volume and weight of the more saleable gums. The taste alone detects its presence, for it is very bitter. It exudes from *Acacia Adansoni* of the *Senegal Flora* (*Mimosa Gonakié*, Adanson).

The *Friable Gum*, or *Sabra-béida* (corrupted into Salabréda), is offered in the form of a coarse salt; its fracture is glassy, the surface always dull and often wrinkled, and it is found either in rounded tears, or in long, vermicular fragments; the flavour is always rather bitter. Its different colours, whitish, red, green, and yellow, depend on the age and strength of the gum tree which affords it; the more or less sandy nature of the soil has also a marked effect. It melts readily in its own weight of water, and forms a thin mucilage, which slightly reddens litmus-paper. January, February, and March are the times when it is collected, in the forests not far from Bakel; and it is sold by stealth, by the Moors, and as fast as they can gather it, for it will not bear to be buried, like the Gum of *Acacia Verek*. It is produced by an *Acacia*, nearly allied to *A. albida:* the tree is very thorny, much smaller than *A. Verek*, and grows in the sands of the Sahara, near Galam, on the right bank of the river. The white bark gives it the name of *Sabrabéida* (the White Tree); its gum is very inferior to the hard gum, and is never vended at St Louis, except when the harvest of hard gum fails. (*Hooker's Journal of Botany*, Feb. 1857).

Anacharis Alsinastrum.—This plant, according to Caspary, is *Serpicula occidentalis* of Pursh, a species which is not found in Europe, nor anywhere in the Old World. It is common in temperate and tropical America, and has been introduced into Britain.—(*Botan. Zeitung*).

Cajuput Oil.—The green colour of the oil of *Melaleuca Cajeputi* according to Reinwardt, is said to be due to the copper vessel from which it is distilled.—(*De Vriese, Pl. Bat. Orient.*)

Parthenogenesis.—Naudin has lately confirmed the views of Bernhardi and others relative to Vegetable Parthenogenesis, or the production of fertile seeds without the contact of pollen. He performed experiments on the pistilliferous plants of Hemp and Bryony, as well as on plants of *Ecbalium Elaterium* and *Ricinus communis.* —(*Comptes Rendus*, 1856.)

Pinea de Terra of Spain.—Dr A. Harvey of Southampton writes, "I send you a small parcel of the seeds of a species of Pine which grows in Spain, and is just now attracting the notice of our railway companies,—its timber being singularly hard and heavy, and, as far as appears, remarkably durable.

"The comparatively short time that ordinary *sleepers* last, and the necessity there is for constantly renewing them, makes the annual charge, on the side of working expenses, in the item of sleepers alone, a very heavy one to our railway companies. And, if it be true, as I am told it is, that, over the kingdom generally, as many as six or seven millions of sleepers are required annually for the purpose of mere replacement, it is plain that, should sleepers made of this Spanish Pine last anything like twice as long as ordinary sleepers do, the saving to the railway interest would be enormous.

"But however this may be, these Spanish sleepers are at this moment commanding a high price in the market, and so eagerly are they sought after, that it is difficult at present to supply them largely enough to meet the demand.

"There are, I understand, vast forests of this kind of Pine growing in Spain, particularly in the neighbourhood of Bordeaux. It is called in the country *Pinea de Terra*, but is, I suppose, the maritime variety of the *Pinus Pinaster*. It is so hard that it cannot be creosoted; and it is said that, by burying the cut timber in the moist sand on the sea-shore (which they are in the way of doing in Spain, at low water), its density is so increased after some weeks' or months' immersion there, as to render it almost imperishable, and make it incapable of being sawn or planed."

Berkeley's Introduction to Cryptogamic Botany is a most elaborate work, containing a full account of the structure and arrangement of Cryptogamic plants. It supplies a want which has been much felt of late in Britain. The work is well worthy of the distinguished author. It is intended, however, only for those who have already acquired some general knowledge of botany. There is the want of a table of contents which would certainly have been a most valuable addition. After giving some introductory remarks on the relation which cryptogams bear to other plants, the author proceeds to give a minute account of the structure and physiology of the Order. He considers the plants under the two divisions of thallogens and acrogens. The former are defined as mostly herbaceous, or provided with foliaceous appendages; foliaceous appendages, if present, destitute of stomata. Spores rarely producing a prothallus; and if so, giving rise to a second order of spores germinating at definite points. Spermatozoids not spiral. The latter are defined as mostly herbaceous, and provided with distinct, often stomatiferous foliaceous appendages. Spores for the most part producing a prothallus, or if not, complicated fruit, by means of the impregnation of an embryonic cell; spermatozoids spiral. There is at the end a list of some of the most useful works, and memoirs relating more or less to cryptogamic botany in general, and its several branches. The work is one which ought to be in the hand of every botanist who wishes to know the state of cryptogamic botany at the present day.

Schleiden's Handbuch der Botanischen Pharmacognosie has been published at Leipzig. It is a useful work for those who are studying the botanical character of vegetable products used in pharmacy. There are eighty-two woodcuts, showing forms and structure of roots, stems, leaves, fruits, starch, &c.

Dr Asa Gray's First Lessons in Botany and Vegetable Physiology.—This excellent popular work is intended for schools. It is illustrated by upwards of 366 wood engravings, from original drawings by Isaac Sprague, and there is a copious glossary or dictionary of botanical terms.

Dr Asa Gray's Manual of the Botany of the Northern United States, 2d edit.—This work contain descriptions of the United States plants, and ought to be in the hands of every one who wishes to study the northern flora of the States. It is drawn up by an eminent botanist, thoroughly competent for the task. The mosses and liverworts are described by Wm. S. Sullivant, a well-known cryptogamist.

Mr Sullivant's contribution has been also published in a separate form.

Phycologia Australica. By Dr HARVEY.—This work has been announced as preparing for publication. It is to contain figures and descriptions of Australian seaweeds.

An illustrated work on the marine botany of Australia, on the plan of the "Phycologia Britannica," will, it is thought, be acceptable to algologists generally, and especially to those who possess a share of the duplicate specimens of Australian algæ distributed by Professor Harvey. Materials amply sufficient for a much more extensive work than that now contemplated have been collected in Dr Harvey's recent tour; but it is thought that a sufficient illustration of the subject may be given by publishing a selection of three hundred of the more characteristic and remarkable species. This number will allow for the full illustration of all the genera, and of the principal sub-types comprised within each genus.

Filices Exoticæ.—Messrs Reeve announce the intended publication of this work by Sir W. J. Hooker. It will contain figures and descriptions of exotic ferns, particularly of such as are most deserving of cultivation.

The drawings and lithographic plates will be executed by Mr Fitch, who is acknowledged to stand unrivalled as a botanical artist; and Sir William Hooker has undertaken to edit the work, and to furnish the descriptive matter. The Royal Gardens of Kew would in themselves afford ample materials for such a work, as the late catalogue of genera and species prepared last year by the able curator, Mr Smith, abundantly testifies, although the *Lycopodiaceæ*, or Club Mosses,—plants of exquisite beauty long supposed to be of difficult cultivation, but now amounting to numerous species in our collections,—are there excluded; and it is well known that no section of the fern-kind requires more accurate illustration, and that none is more difficult to determine.

CHEMISTRY.

Artificial Formation of Sapphires. By M. GAUDIN.—Twenty years since M. Gaudin obtained artificial rubies by fusing ammoniacal alum before the oxyhydrogen blowpipe, with the addition of a small quantity of chromate of potash. He has now succeeded in preparing perfectly isolated and colourless crystals of alumina in the form of the sapphire. For this purpose he introduces into a crucible, lined with charcoal, equal weights of alum and sulphate of potash, both previously calcined and reduced to a fine powder, and exposes the crucible for a quarter of an hour to the full heat of a forge. When the crucible is broken, the crevices of the lining are found to contain a mass consisting of sulphuret of potassium, through which are disseminated the crystals of alumina. The mass is treated with dilute *aqua regia*, and the crystals left in the form of a fine sand, which is well washed with water. The crystals vary in size, according to the mass of the materials employed and the duration of the heat; those obtained by M. Gaudin, operating on a small scale, were about a millimetre in length. They are colourless, because in this process any metallic oxides which may be added for the purpose of imitating the natural colours of the sapphire are reduced by the charcoal. They are extremely limpid, and surpass natural rubies in hardness. The formation of those crystals depends on the solvent action of the sulphuret of potassium, and by means of this substance, as well as by the chlorides, fluorides, and cyanides, M. Gaudin thinks it will be possible to obtain many other insoluble substances in crystals.—(*Comptes Rendus*, vol. xliv., p. 716.)

Occurrence of Fluorine in the Mineral Waters of Plombieres, Vichy, and Contrexéville. By M. Nicklès.—According to M. Nickles, these waters all contain fluorine, the first two in very small, the latter in larger quantity. Its presence was determined by treating the solid residue with pure sulphuric acid, and allowing the vapours of hydro-fluoric acid to act on plates of rock-crystal. He states that, in making such experiments, plates of glass must be rejected, as they are corroded by sulphuric acid, and that even when rock-crystal is employed, it is necessary to purify the sulphuric acid with silica, in order to expel traces of hydro-fluoric acid, which he says are usually found even in the distilled acid.—(*Comptes Rendus*, vol. xliv., pp. 679 and 783.)

A New Oxide and Chloride of Silicon. By M. Wöhler.—When silicon is exposed to a current of dry hydrochloric acid gas at a low red heat, hydrogen gas is evolved along with a new chloride of silicon. It is a liquid forming in the air, and more volatile than the ordinary terchloride. Water decomposes it, yielding hydrochloric acid, and new oxide in the form of a white powder, scarcely soluble in water, but very soluble in the alkalies,—even in ammonia, hydrogen gas being disengaged, and silicic acid produced. Heated in the air, it catches fire and burns with a white flame.—(*Comptes Rendus*, vol. xliv., p. 824.)

On the Existence of Circular Polarization in Cinnabar and Sulphate of Strychnine. By M. Descloizeaux.—It is well known that rock-crystal is the only mineral in which circular polarization, and the remarkable connection between this property and the position of the plagihedral faces, has been observed. As far as hitherto known also, circular polarization is confined to singly refracting crystals, or crystals with only one axis of double refraction. M. Descloizeaux has now detected this property in cinnabar, which very closely resembles rock-crystal in this respect, for he has found both right and left handed crystals, as well as compound crystals, producing the phenomena observed in amethyst and the Brazilian rock-crystal. Its rotatory power is much more considerable than that of rock-crystal, for he found that a plate 0·2 millimetres in thickness produced a rotation of 54° to 60°, while

Biot ascertained that a millimetre of rock-crystal rotates only 18°. The rotatory power of cinnabar is therefore about fifteen times as great. It is worthy of notice, that in the very complete crystallographic examination of cinnabar made by Schabus in 1851, no mention is made of plagihedral faces; but as these might easily have been overlooked, M. Descloizeaux resolved to make a more minute examination of its crystallographic forms. The anhydrous sulphate of strychnine also possesses circular polarization. but only left-handed crystals have as yet been observed; its rotating power is 1·5, that of rock crystal being 1.—(*Comptes Rendus*, vol. xliv., pp. 876, 909.)

GEOLOGY.

Tertiary Fauna of Greece—The Pikermi Fossils.—In September last a collection of fossils was brought to Paris from Greece by Messrs Larte. and Gaudry, and described in a memoir submitted to the Academy of Sciences. They were found at Pikermi, a village twelve miles E.N.E. from Athens (supposed by Major Leake to occupy the site of the ancient Attic Demus Epacria). It stands at the south-east foot of Pentelicus, in a ravine cut by streams descending from that mountain, and about four miles from the Ægean Sea. The collection is remarkable for the singular variety of species it includes, of which a few were mentioned, viz:—Semnopithecus, a monkey; a hedgehog, or perhaps castor; two giraffes, one taller than the living species; a huge edent quadruped, resembling the sloth in form, named by them *Macrotherium Pentelicum*, as large as an elephant; with various bones of gallinaceous birds; but no fishes or reptiles. They consider the deposit as intermediate between the Molasse and the Subappenine marls—miocene or lower pliocene.

The fame of these fossils had also spread to Germany, and Dr Roth, a Bavarian, after spending many months in exploring the deposit, has brought home a rich collection of the bones, which are described by himself and M. Wagner in a report to the Royal Academy of Munich. They make a large addition to those above named, including remains referable to no less than nineteen distinct species of quadrupeds. The monkey, in Dr Roth's opinion, is not the Semnopithecus, but an animal intermediate between that and the gibbon. He found five species of carnivora—1. A viverrine, which he has named *Ictitherium*; 2. A glutton, *Gulo Primigenius*; 3. A hyæna (*H. eximia*); 4. A wolf, smaller than the living European one; 5. A leonine animal, *Machœrodus*, larger than the living lion or tiger; 6. A rodent, *Lamprodon* (beaver) believed to be a hedgehog by Lartet; 7. An edent, the *Macrotherium* previously mentioned; 8. The *Hippotherium gracile*, or ancient horse, whose bones were so abundant as to enable Dr Roth to construct a complete skeleton; 9. Three jaw-bones of an animal termed *Hipparion*, a doubtful species, supposed to have been a three-toed horse; 10. *Sus Erymanthus*, a hog larger than the wild boar; 11. The femur of a *Mastodon*; 12. Part of a cranium with five teeth of a rhinoceros. Of ruminant animals there are the remains of five species of antelopes, a goat, and an ox (*Bos Marathonius*) larger than the bison. Of the nineteen species of extinct animals exhumed from this rich deposit, thirteen are considered new. Dr Roth met with no bats or insectivora, and Lartet and Gaudry, as already stated, found no fishes or reptiles. The bones were much broken, and no complete skeleton was found with all the parts united.

Now, this singular assemblage of bones was found at the foot of Pentelicus, on the south side, at a point where several streams unite, just in the position where we would expect to find them if the animals had lived and died on the mountain, and left their spoils to be swept down by rains and torrents and buried in the mud and sand they brought with them. Is this, then, a picture of the fauna of Attica towards the end of the tertiary period—thousands of years before man existed? Were races so dissimilar denizens of the mountain at the same time? Did the giraffe, the monkey, the horse, the ox, the goat, the antelope, the hog, dwell in company with the mastodon, the rhinoceros, the lion, the wolf, the hyæna?—and upon a single mountain of very limited extent? In Major Leake's map of Attica, Pentelicus is only nine or ten miles long, its breadth cannot exceed three miles, and its height, if our memory may be trusted, does not exceed 3000 feet. In the living world are there spots where a fauna so diversified and heterogeneous exists within so narrow a space—narrow even if the animals belonged to all Greece? Does it not look rather like a group collected from different countries and different climates? This is, in reality, the conclusion to which Messrs Lartet and Gaudry arrived. Founding on the apparent improbability of so many and such gigantic animals living on a peninsula so narrow as Greece, and so intersected by elevated chains, they have been led to suppose that the Greece of our days and its isles are only the *debris* of a great continent (which they term Greco-Asiatic) now buried under the waves of the Archipelago and the Mediterranean. It was in this state when the hippurite limestone (a member of the chalk formation) was deposited, and afterwards the nummulitic or lower tertiary. The whole was then raised up, forming one continuous range of land with Asia Minor. Upon this land the extinct quadrupeds of Pikermi lived, and here the animals of Armenia, Syria, and Arabia might meet and mingle with those of Illyria and Thessaly. Subsequently, two great lines of fracture, nearly at right angles to each other, shattered this Greco-Asiatic continent, sinking the part of it which forms the Ægean Sea, separating part into islands, and leaving Greece something like the present. A yet later movement, "de bascule," or see-saw, like the two ends of a scale-beam, depressed the southern part of the country under the sea, about the Subappenine period, and forced the land animals to seek refuge in the mountains; those in or near the plain of Athens escaped to Pentelicus, where, cooped up within a narrow space, they perished from insufficiency of food, and their bones, exposed to the elements, were washed down by rains and torrents to the ravine of Pikermi. The bones, with the exception of a monkey, are those of quadrupeds only, because we presume the slow-paced reptiles had not time to save themselves; and no fish are found, probably because the Subappenine sea had not remained long enough at the foot of the mountain to allow the finny tribes to settle and breed.

Few men are so well qualified as M. Lartet by their previous labours to throw light on the problem of the Pikermi bones. We owe to him nearly all our knowledge of the still richer and more varied collection of fossils discovered in the lacustrine deposit at Sansan, close to the north foot of the Pyrenees, which is as great a riddle as that of Pikermi, and not yet solved. From that spot and the adjacent localities of Simorre, Lombez, and Tournan (department of Gers), M. Lartet disinterred no less than ninety-eight genera, subgenera, or species of mammalia and reptiles, a gigantic bird (*Pelagornis*), and some fresh-water fishes. Among the quadrupeds are nearly all those found fossil over the rest of France, and representatives of nearly all the mammalian family—the plantigrade Carnivora, except the bears properly so called, the digitigrade Carnivora, the Edentata, Rodentia, Pachydermata, and Ruminantia, and also a bat and a monkey. Among the genera belonging to these families we have the rhinoceros, elephant, mastodon, deer, antelope, tapir, hog, dog, wolf, civet, marten, hyæna, ox, paleotherium, anoplotherium, and dinotherium. They exceed the Pikermi fossils in variety as much as the Pyrenees exceed Pentelicus in length and breadth. The late M. Prévost, an able geologist, attempted to explain how so many land animals were swept into one small fresh water lake (*Bulletin de la Société Géologique*, 1847-6, p. 338), but D'Archiac, a very high authority, pronounces his explanations a failure.—C.M.

Kidderminster Deposits—Cambrian Rocks—Malverns—Hollybush Sandstone.—We have been informed by the President of the Malvern Natural History Field Club (Rev. W. S. Symonds), that a large annelid, *Trachyderma antiquissima*, Salter, has been detected by Dr Grimshod in these deposits. This gentleman has probably made a still more important discovery in the lower Ludlow shales, but which awaits further investigation.

Kidderminster Passage Beds of the Upper Tilestones into Old Red Cornstones.—The organic remains of these deposits have been determined by Sir P. de Grey Egerton and Mr J. W. Salter.

Fishes—	Old Red fossils.
Cephalaspis Lyellii,	
C. Lloydii,	
Crustacea—	Upper Silurian fossils.
Pterygotus problematicus,	
P. Anglicus,	
Pteraspis Banksii,	
P. ornatus,	
Plants—Very abundant, with Parka decipiens.	

Generalities of the Geology of Northern California and Oregon.—At the Albany meeting of the American Association, Dr Newberry gave a general view of the geology of Oregon and that part of California lying north of San Francisco, and of the age and structure of the three ranges of mountains which, he said, gave character to the topography of the Far West, and of the valleys which lie between them. These "valleys," he said, were rather plains or plateaus than valleys. The Sacramento Valley was a plain lying between the Coast Range and Sierra Nevada—for the most part destitute of trees—through which the river ran with tortuous course, like a brook in a meadow. In the lower part of the Sacramento Valley, there were no rocks older than tertiary; but at the head of the valley he had found the carboniferous limestone—clearly marked by its characteristic basalts, on which were lying the cretaceous and tertiary strata, precisely as on the Upper Missouri.

Crossing the volcanic spur of the Sierra Nevada connecting Mount Shasta with that great chain of mountains, he had descended into the Klamath Basin, which he said formed an appendage to the great basin of the Salt Lake, and was a plain somewhat cut by subordinate ranges of mountains, lying at a considerable elevation, and containing a large number of lakes, of which the Klamath were the most important. This basin was drained through the cañons of Pit river, the largest tributary of the Sacramento, which, like the Klamath river, had forced its way through the mountain ranges which lay between the basin and the sea; Pit river flowing through an impassable cañon nearly an hundred miles in length. The Klamath basin was once to a much greater extent covered by water than now; and before it was so perfectly drained as now, its waters deposited a variety of strata, some of which were as white and fine as chalk, though having a very different composition.

He said further, that the basin or plateau of the Des Chutes was not separated by any barrier from that of the Klamath lakes, and exhibited all its peculiar features still more strongly marked. The Des Chutes basin was a plateau lying between the Cascades and the Blue Mountains, and, with the Klamath basin, belonged, from its topography, geology, fauna, flora, and climate, to the great central basin. Like the Klamath basin it was once covered with water—was a lake drained by the Columbia, as now, but not so perfectly drained. The Columbia had been gradually deepening its bed. The Des Chutes Lake, as it then was, had deposited sediments to the depth of 2000 feet or more, for the streams which now traverse it have cut cañons in this plateau to that depth. These sediments were covered by a floor of trap which had been poured evenly over the whole surface—which had not been subsequently disturbed, and when broken open, exhibited a columnar structure—the columns being quite perpendicular, and sometimes one hundred feet in height. Below the trap was a series of strata exhibiting all possible varieties of volcanic tufa, some very fine and chalky, others coarser; and the different layers, which were from two to ten feet in thickness, and perfectly parallel, were coloured with all the hues of the rainbow—red, green, yellow, blue, orange, pink, white, &c., and as highly coloured as a geological chart for a lecture room. It had often happened to him, travelling over this plateau, to come suddenly and without any warning to the brink of one of these cañons two thousand feet deep, at the bottom of which a stream was flowing.

The Cascade Mountains, he said, were not a simple chain, but a broad belt of mountain peaks, sometimes fifty miles or more in width, many of the summits being covered with perpetual snow, the passes being generally about 7000 feet in height. He had found extensive proofs of the existence, at a former period, of glaciers capping the Cascade range, and extending far below the present limit of perpetual snow. The Cascade range was eminently volcanic, abounding in craters, lava fields, and congealed lava streams, all as fresh and ragged as though just poured out from some volcano; indeed, Mount Hood and Mount St Helens may still be considered as active volcanoes, giving off gases and steam continually, and within a few years have emitted showers of ashes.

Professor N.'s theory of the excavation and filling of the valleys of California and Oregon was, that at one time, probably at a period corresponding with that of the drift in the Eastern States, all that portion of the continent was raised to such an altitude as to produce a degree of cold which covered the mountains and filled the valleys with ice. By this ice the surfaces of rock were worn down, and the marks of glacial action which now abound produced. The valleys were excavated in part by this process. As the continent was depressed, the valleys were occupied by water, in which the ashes from ranges of active volcanoes were discharged and arranged in strata of sediment. As the drainage of these basins progressed by the cutting down of the outlet, they were gradually converted to the dry plains which they now are.

Among other points of interest in the geology of the West which were touched upon, was the geological age of the coal deposits of Oregon and Washington territories, all of which Prof. N. said were tertiary, and were associated by unmistakeable tertiary fossil plants.—(*Wells's Annual.*)

New Fossil Shell from the Connecticut River Sandstone.—Mr E. Hitchcock, Jr., in a communication to "Silliman's Journal," states that he has recently found in the coarse sandstone of Mount Tom (Easthampton, Massachusetts), a shell of a mollusc, the first, he believed, that has been discovered in the sandstone of the Connecticut Valley. It is preserved, and not petrified, and a considerable part of it has disappeared. Enough remains, however, to enable us to refer it to a family, if not to a genus of shells. The upper part is gone, leaving an oval opening about an inch and three quarters in one diameter, and an inch and one quarter in the other. It extends downwards, tapering somewhat rapidly nearly an inch and a-half, and is left without a bottom, the lower opening being about an inch wide. The walls are very thick, in some places nearly half an inch, and made up of several concentric layers. From the resemblance of this shell to a model of the lower valve of the *Sphærulites calceoloides* in the Cabinet of Amherst College, it seems probable that it may be referred to that family of Brachiopods denominated Rudistæ by Lamarck. Its lower parts, as well as the lower valve, are missing, but what remains approaches nearer to the genus Sphærulites than to any other of the Rudistæ of which he has seen specimens or figures. This fossil seems to lend additional strength to the inference derived from the discovery of the Clathropteris, that the upper part of the sandstone of the Connecticut Valley is as high at least as the Liassic or Jurassic series. It might seem even to carry us higher in the series, but it would be premature to draw such an inference from a single imperfect specimen, even though its true analogies be ascertained. The specimen now belongs to Amherst College Cabinet.—(*Wells's Annual.*)

PHYSICAL SCIENCE.

New Planets Discovered in 1856.—The number of planetary bodies belonging to the solar system has been increased during the past year by the discovery of five new asteroids. The whole number of the asteroids at present date is forty-two.

The thirty-eighth asteroid, appearing as a star of the 10th magnitude, was discovered by M. Chacornac at Paris on the 12th of January. It has received the name of *Leda.*

In announcing this discovery to the French Academy, M. Leverrier remarked, that he was now convinced that a large number of small planets exist between Mars and Jupiter, and that before 1860 probably as many as a hundred will have been detected.

On the 8th of February, M. Chacornac also discovered the thirty-ninth asteroid, which appears as a star of the 9th magnitude, and has been called *Lœtitia.*

On the 31st of March, M. Goldschmidt at Paris discovered the fortieth asteroid, *Harmonia.* It appears as a star of the 9-10th magnitude.

On the 22d of May, M. Goldschmidt discovered the forty-first asteroid, *Daphne*, appearing as a star of the 11-12th magnitude.

On the 23d of May, the forty-second asteroid, *Isis*, was discovered by Mr Poyson, of the Radcliffe Observatory, Oxford, England. It was then rather brighter than a star of the 10th magnitude.—(*Wells Annual.*)

On the Original Asteroid Planet.—In a paper read to the American Association, Albany, Professor Alexander succinctly re-stated the principal features of his hypothesis advanced last year, viz., that there was originally but one planet between Mars and Jupiter, and that this, instead of the ordinary form, approximating closely to a sphere, had the shape much very like that of a very thin wafer, the equatorial diameter being enormous in comparison with the polar. In one determination of the equatorial diameter, he made use of the mass of the planet derived from a new relation of masses and distances, which itself seemed to be a consequence of the nebular hypothesis. Four other determinations were, however, given in that connection; but that which included the most extensive relations was also the most consistent with other and independent results.

The other method of obtaining the equatorial diameter consisted, as before, in determining and applying the difference of the velocity of those asteroids which approach most nearly to one, and live in their aphelia and perihelia respectively.

The two independent results were as follows :—

Equatorial diameter, ... $\left\{\begin{matrix}75,094\\63,846\end{matrix}\right\}$ miles.

The polar diameter must have been very small, as it was independent of the density. With a density equal to that of the earth, it would be only from about 8½ to 11½ miles. No less than eleven facts were stated, which this hypothesis would reconcile. The recently discovered asteroids had the position of their orbits represented, and the inclination of the orbit of the original planet was deduced anew, and found to be about 4 deg. 20 min.—(*Well's Annual.*)

Parallax of the Fixed Stars.—M. Struvé, the astronomical director of the Pulkowa Observatory, Russia, in his recent annual report, says:—In my astronomical pursuits the parallaxes of fixed stars have taken a prominent part during the last year, and I think I have made a considerable progress in these researches. Now that the methods of observation are entirely fixed, I am quite sure that if there is a difference of parallax of $0''\cdot1$ between any couple of stars situated at a distance less than 5′ from another, four observations made at the epochs of maxima and minima will be entirely sufficient to prove its existence, and to define its amount within very narrow limits.

A short review of my observations shows that μ Cassiopeiæ has a parallax of more than $0''\cdot3$, η Cassiopeiæ of more than $0''\cdot2$, and Capella of between $0''\cdot1$ and $0''\cdot2$. For all these cases, the results obtained by the angles of position agree remarkably with those furnished by the distances. The observations of other stars, namely of α Tauri, α Aquilæ, α Andromedæ, and α Cassiopeiæ, are about to be closed; but to guard me against any pre-occupation, not even the first step has been made for the reduction of these observations.—(*Wells's Annual.*)

Observations on Saturn.—At a late meeting of the American Academy, Mr W. E. Bond exhibited some diagrams of the planet Saturn, and mentioned various facts concerning it; namely, that the inner edge of the rings is constantly approaching the planet itself; that the ball is seen through the rings, which are consequently transparent; that the colour is different in different parts of the rings, the equatorial regions being white, the temperate region reddish, and the polar bluish. He also mentioned that the shadow of the ball upon the ring can be seen on both sides of it, being on one side rather faint, but on the other quite decided. This anomalous appearance he first noticed in October 1852, and as yet he could give no satisfactory explanation of it, nor of the singular shape of the shadow, the convexity of which was towards the ball instead of from it, as it might be expected to be. His observations were made with the great Cambridge refractor in the years 1852, 1854, and 1855.

Professor Pierce, at the American Association, in a discussion on the constitution of Saturn's ring, observed that the analogy between the ring of Saturn and the belt of the asteroids, was worthy of notice. It was to be remembered that in order to have Saturn's ring remain continuous and flattened into so thin a sheet, the radial or vertical tide in the ring produced by the satellites must be neither too large nor too small. But if the solar system were formed according to the nebular hypothesis, the tides in the remaining mass, after the formation of Jupiter, must have been, from his great size, extraordinarily great, and have produced a different sort of ring at the distance of the asteroids from those produced for the other planets.

Mr Vaughan observed that the orbits of interior planets would render those of exterior ones circular, as grinding a stopper in the neck of a jar rendered it circular.—(*Wells's Annual.*)

Solar Spots.—The following is an abstract of a paper communicated

to the American Association on the above subject by Dr Peters of Denmark :—

His conclusions, he said, were drawn from observations made in Naples in the year 1845-6. He and his collaborateurs had computed eight hundred and thirteen heliographic places of two hundred and eighty-six spots. They had ascertained that the spots were not invariably attached to the sun's surface, but that they had motions of their own. These motions were a general tendency to move towards the equator, and where a new spot broke out in the neighbourhood of another, the old one moved away from it as if it were pushed away. New spots generally broke out to the east of old ones, and had a motion towards the west, and the motions in longitude were far more considerable than those in latitude. These motions were in some instances at the rate of three or four hundred miles in an hour. Two zones of the sun's surface were particularly fruitful in spots ; the maximums occurring at the parallels of 21 degrees of north latitude, and 17 degrees of south. Instances had been noticed in which spots reappeared after an interval of two or three hundred days, although there was one difficulty in determining this accurately, arising from the uncertainty of the time of rotation. Since spots arose from invisible points at the exact moment of their origin, they could not be studied.

The first indication which the telescope revealed was a sort of bubbling agitation in the luminous layer. To this succeeded a small spot, which rapidly attained its full size—almost always in the course of a day. They remained in this, the vigorous epoch of their life, with a well-defined penumbra of regular and rather simple shape, for ten, twenty, and sometimes even for fifty days. But at last their time came. Their margin had always been slightly notched, and soon the notches grew ominously large and deep, penetrating far into the mystic realm of darkness, while hostile columns of light arose, as if by magic, occupying the centre. Deeper and deeper grew the invading notches, until at last electric flashes passed between two of the more prominent, across the disc. The victory was gained, the centre pierced, and the spot divided into two, after which it was very easy to cut it up in detail. Dr Peters explained these facts by the assumption of volcanoes sending up gaseous matter which parts the luminous covering. All the world knows that the sun is supposed to have at least two atmospheres,—the one next its surface dark but supporting another which is luminous, and which sends forth light and heat.—(*Wells's Annual.*)

Photographic Astronomy.—Those interested in the progress of astronomy may recollect, that about six years ago an account was published in the "Boston Traveller" of daguerreotype impressions of the stars Vega and Castor having been obtained at the Observatory of Harvard College, by the aid of the great equatorial telescope. This was the first successful attempt to procure photographic images of any of the fixed stars that has come to our knowledge ; but at that time it was found impossible to extend the process to stars of lesser magnitude. This was attributed to the want of sufficient susceptibility in the daguerreotype plates, and the deficiency of power and regularity in the machinery designed for giving the telescope a uniform siderial motion.

These deficiencies have been recently supplied ; first, by the construction of a driving clock on the principle of the spring governor, in which the rotary motion of the fly-wheel is regulated by an oscillating pendulum, which has been found, from several years' practical application, to be the most perfect regulator of rotary motion yet devised. A machine of this description has been adapted to the great telescope by those excellent mechanicians, Messrs George and Alvan Clark of East Cambridge, assisted by their father, Mr Alvan Clark senior. This point having been satisfactorily accomplished, we obtained the assistance of Messrs Whipple and Black, whose skill as daguerreotypists is unsurpassed. We knew them to be deeply interested in the success of these experiments, and it is to those gentlemen that we are principally indebted for whatever of success has crowned our efforts in the perfect delineation of stars of the lesser magnitudes, and of the group of stars composed of Mizar and its companion, and Alcor, and also of other stars ranging from the first to the fifth magnitude, evidencing that all stars usually visible to the unassisted eye may be mapped by the aid of photography with a degree of accuracy unsurpassed by the most refined measurements. Of this accuracy we have abundant testimony by measuring the distances of the photographic images taken on different nights.

The last report of the Council of the Royal Astronomical Society of London contains the following paragraph :—

"We may remind our readers that no one has at present produced on our table a photographic image of a fixed star. A good or even a moderate photographic image of a group such as the Pleiades would be something we have not yet had the pleasure of seeing; and a fair approach to getting an instantaneous image of a group of faint points might lead the way to results of great importance."

The connection of photography with astronomy has thus become most intimate, and combined with the electro-magnetic method of recording astronomical observations, seems destined to effect a complete revolution in the methods formerly pursued in observing the positions and physical conditions of the heavenly bodies.—W. C. Bond.—May 7, 1857.—(*Boston* (*U.S.*) *Daily Advertiser.*)

Notice of a Powerful Electric Induction Coil constructed by E. S. Ritchie of Boston, U.S.—(Communicated by Prof. William B. Rogers.)—An induction apparatus has lately been constructed by Mr E. S. Ritchie of Boston, which greatly exceeds in power the French Ruhmkorff apparatus, and surpasses even the most energetic of the improved coils described by Mr Hearder of Plymouth. Of the first of Mr Ritchie's instruments a short notice was published in the May number of "Silliman's Journal." In this the secondary wire, about seven thousand feet in length, is wound in the usual way, by continuous layers reaching from end to end of the spool. The condenser is made of sheets of tin-foil, separated by double sheets of varnished paper. The primary current is derived from four Bunsen cells, arranged for intensity. When in action this instrument affords a spark in the air between the terminals of the induction coil of from 2 to 2½ inches long.

In the more powerful apparatus since constructed by Mr Ritchie, he has adopted an ingenious mode of winding the secondary wire, which has the effect of dividing the coil into a multitude of flat rings. The advantage of such an arrangement had already been suggested by Poggendorf, but without any attempt to carry it into effect, or any intimation as to how it might best be done. In order to obtain the result, Mr Ritchie begins the winding at one end of the spool by laying down the wire in successively widening circuits *on a conical surface*, having a steep slope towards the cylinder of the spool. After covering the conical surface with a layer one wire in thickness, the wire is carried down to the spool to commence a second similar layer, and thus on to the end of the spool; the successive layers being separated by rings of gum elastic, and the wire imbedded, as the winding proceeds, in non-conducting current. When wound in this way, it is evident that the contiguous parts of two adjoining layers cannot be separated by a length of wire, counting along the coil, greater than the length of wire in the conical layer. Hence but little difference of tension can exist in the current of adjacent layers, and therefore but little tendency to a discharge across the interposed non-conducting material.

In this apparatus the secondary coil consists of about thirty thousand feet of very fine wire, wound in the manner above described, and the primary of only a few hundred feet of a very thick wire, the two being separated by the walls of a thick and rather narrow bell-glass, so as effectually to insulate the one coil from the other. The condenser is constructed as in the first instrument, but with a larger surface.

Using the current from four Bunsen cells, which has been found to give as great effect as a larger number, we obtain between the terminals of the secondary coil, in free air, *a spark ranging from five and a-half to six and a-half inches*; while, as might be expected, the other phenomena exhibited by the apparatus are of extraordinary energy and splendour.

MISCELLANEOUS.

Obituary of Persons Eminent in Science: 1856.—Admiral Beechey, R.N., a distinguished Arctic navigator and geographer. Henry Bellville, an English meteorologist. A. Binet, an eminent French mathematician, formerly President of the French Academy. Professor Bojer, a well-known French botanist. W. M. Buchanan, editor "Glasgow Practical Mechanics' and Engineers' Journal." Dr Buckland, the well-known English geologist. Alex. Campbell, a distinguished American engineer. Adrien Chenot, a celebrated French metallurgist. M. Coutourier, a young French explorer of Central Africa; died on the Sahara. Joseph Drayton, the well-known artist of the U.S. exploring expedition, and a naturalist of eminence. M. Duval, a French botanist. David Dyson, an English naturalist. Professor von Fuch, the well-known German physicist and chemist. M. Gerhardt, the eminent chemist of Strasburg, France. M. Goujon, a French astronomer. Dr W. T. Harris, the eminent American entomologist. Professor Hentz. Dr John Lock of Cincinnati. M. Loewell, a German chemist of repute. Colonel Madden, President Edinburgh Botanical Society. C. B. Mansfield, of England, well known for his researches in connection with benzole. François Michaux, editor North American "Sylva." Hugh Miller, the eminent Scottish geologist and author. Francisco Orioli, Professor of Physical Science, University of Bologna. M. Partsch, of Vienna, naturalist. Dr W. H. Paris, an eminent English chemist, and friend of Sir Humphrey Davy. Dr Paris was the author of the well-known work, "Philosophy in Sport," &c. J. G. Percival, geologist, &c. M. Constant Prevost, the distinguished French geologist and physicist. John Reeves, an English horticultural writer. Admiral Sir John Ross, the Arctic explorer. M. Schwilgue, the inventor of the marvellous astronomical clock of Strasburg. Daniel Sharp, President Royal Geological Society, England. George Steers, the distinguished naval architect. Robert L. Stevens, a distinguished American mechanic. Paul Stillman, a distinguished American engineer. M. Sturm, French mathematician. William Swainson, the well-known English naturalist. Zadock Thompson of Vermont, naturalist. Dr John C. Warren, Boston, Massachusetts. James Wilson, a Scotch naturalist. William Yarrell, naturalist.—(*Wells's Annual.*)

Death of Dr Robert Ball.—Since our last publication, we regret to have to announce the death of Dr Robert Ball, an esteemed naturalist, whose name was recently brought under notice in connection with the arrangements for the next meeting of the British Association. Dr Ball was born in 1802. He succeeded the late Dr Whitly Stokes as director of the museum in Trinity College. On the establishment of the Queen's University in Ireland in 1851, he entered on the additional duties of Secretary of the Joint Committee of Lectures in connection with the department of Science and Art, and in 1855 he was nominated Assistant Examiner for Ireland to the Civil Service Committee. While holding these several appointments, he was an active member of most, if not of all, the scientific societies of Dublin. He is best known as Secretary of the Royal Zoological Society of Ireland, and as Treasurer of the Royal Irish Academy, an office next in corporate rank to that of President. In 1850 the University of Dublin conferred on him the honorary degree of LL.D. His published papers are scattered through the pages of different periodicals. Three have appeared in the Transactions or Proceedings of the Royal Irish Academy, viz., "On the Species of Seals (Phocidæ) inhabiting the Irish Seas," "On the Remains of Oxen found in the Bogs of Ireland," and "On the Cephalopoda of the Irish Seas." That he was at all times ready to impart his information freely to others, most of the zoological works published in these kingdoms during the last few years afford ample testimony.—(*Athenæum.*)

Collections Zoologiques (Oiseaux et Mammifères) rapportées par S. A. T. le PRINCE NAPOLEON BONAPARTE.

Les journaux de 1856 ont entretenu le public du voyage d'exploration entrepris dans le cours de l'eté passé par le Prince Napoléon vers les régions extrémes du Nord de l'Europe.

Vous ont également parlé de l'exposition des objets rapportés par son Altesse, mais ils l'ont fait généralement à un point de vue trop superficiel, pour qu'il n'y ait pas encore à revoir après eux le même sujet.

Laissant d'ailleurs de côté tout ce qui n'est point du domaine de la zoologie, nous passerons encore devant la partie ethnologique de l'expédition, que nous n'avons pû suffisamment étudier pour nous occuper uniquement des collections d'ornithologie et de mammalogie.

Les mammifères, en petit nombre (ce qu'il faut attribuer tant à la nature accidenteé et difficultueuse du pays, qu'au caractère du voyage, destiné seulement à l'exploration des côtes se composaient de quelques peaux de *Felis borealis et cervaria*, de *Phoca groënlandica*, de *Canis lagopus* d'un fœtus *de Balæna* et d'un superbe *Castor fiber*, tué en Norwège, une des rares régions Européennes qui recèlent encore ce curieux animal. Il y' avait pénurie de tous les petits rongeurs du Nord.

La collection ornithologique était de beaucoup, plus importante et plus complète. La partie oologique s'y trouvait notamment représenteé d'une manière brillante.

Voici la liste complète des espèces recueillies par l'expédition, nous la restreignons seulement au catalogue des peaux d'oiseaux.

- Aquila albicilla, Gr.
- Falco peregrinus, Gr,
  - candicans, Gr.
  - islandicus, Isl.
- Strix nyctea, Gr.
- Corvus corax, Isl.
- Emberiza calcarata, Gr.
  - nivalis, Gr.
- Linaria groënlandica, Gr.
  - canescens, Gr.
- Tyrannula pusilla, Gr.
- Lagopus Reinhardtii, Gr.
- Charadrius auratus americanus, Gr.
  - pluvialis, Isl.
  - hiaticula, Gr.
- Strepsilas interpres, Isl.
- Phalaropus hyperboreus, Gr.
- Tringa maritima, Gr.
- Numenius melanorynchus, Gr. Isl.
- Gallinula chloropus, Isl.
- Sula Bassana, Gr.
- Phalacrocorax carbo, Gr.
- Procellaria glacialis, Gr.
- Lestris parasiticus, Gr.
- Larus leucopterus, Gr.
  - marinus, Gr.
  - eburneus, Gr.
  - tridactylus, Isl.
- Sterna arctica, Isl.
- Anser bernicla, Gr.
- Cycnus musicus, Isl.
- Anas acuta americana, Gr.

Querquedula carolinensis ? Gr.
Somateria mollissima, Gr. Isl.
  spectabilis, Gr.
Clangula Barrowii, Gr.
Fuligula histrionica, Gr. Isl.
  glacialis, Gr.
  marila americana, Isl.
Mergus serrator, Gr.
Colymbus glacialis, Gr. Isl.
Uria troile, Gr.
  grylle, Gr.
Mergulus alle, Gr.
Podiceps arcticus, Isl.
Mormon fratercula, Gr.

Les abréviations Gr. Isl. employées à la suite des ci dessus, signifient Gr. Groënland ; Isl. Islande, suivant les localités ou les oiseaux ont été capturés.

Comme on ne manquera pas de le remarquer la plupart des espèces notées ci dessus sont pélasgiennes, cela tient comme nous l'avons expliqué plus haut, au caractère essentiellement maritime de l'expédition du Prince Napoléon, et aux trés courtes relàches à terre des naturalistes attachés à cette intéressante entreprise. Il ne faut pas oublier non plus que ce voyage qui n'a duré que quatre mois s'est opèré pour ainsi dire à vol d'oiseau.

Presque tous les types de la collection de peaux se retrouvent dans la collection d'œufs ; on y remarque en plus un grand nombre *d'Anas*, tous les *Sterna* et *Lestris* de l'Europe septentrionale, des *Tringa*, *Procellaria*, etc. etc., mais de même que dans la collection de peaux ; l'oologie est pauvre aussi en *Passereaux*.

Quoiqu'il en soit de la pauvreté relative de certaines familles, il faut savoir gré au Prince Napoléon d'avoir attaché son nom à l'entreprise scientifique qui a donné ces résultats, ce premier voyage fait espérer beaucoup dans un prochain avenir.

EDM. FAIRMAIRE.

PARIS, *Mars* 1857.

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Mountain Climates considered in a Medical Point of View —(continued). By Dr H. C. LOMBARD.*

If we proceed, from the diseases of frequent occurrence in high localities, to the consideration of such as are more rarely observed there than in the plain, we should mention, in the first place, pulmonary phthisis and other tubercular affections, which are almost unknown to the ancient inhabitants of the soil, the Indians; if insulated cases of them are met with, it is the Creoles who are attacked.

Rheumatism, which the atmospheric circumstances might be supposed likely to develop, is extremely rare in Puna and the southern Sierra.

To these particulars, which we owe to the observations of Dr Tschudi, I shall add some facts derived from other sources. According to Dr Weddel, inflammatory diseases of the organs of respiration are very frequent at Paz, the capital of Bolivia, which is situate, as has been stated, at 12,238 feet above the level of the sea. He attributes this fact to the dryness of the air, and the low temperature which prevails during the night.†

Humboldt has made the same remark in regard to Mexico,

* From the Bibliothèque Universelle de Genève.

† Weddel. Voyage dans le nord de la Bolivie, 8vo, Paris, 1853.

(7470*), where catarrhal affections and inflammations of the lungs are very frequent.

The last fact I wish to state regarding Alpestrine pathology, refers to the Hospice of the Great St Bernard (8129). The Prior of that establishment has kindly replied in the following terms to the questions put to him, at my request, by Professor Plantamour :—" The diseases to which the monks are liable are inflammations of the chest. The greater number of them become asthmatic after a certain number of years, and are obliged to go down again to the plain. Those who have been born among the mountains can reside for a long time with impunity at the convent."

Dr D'Espine, who acquired his knowledge of this subject by a residence at the Hospice upwards of twenty years ago, has confirmed to me the accuracy of these observations. They may therefore be considered as expressing faithfully the influence of Alpestrine climates on those subjected to them for a certain number of years.

In conclusion, we may add that epidemic or contagious diseases are not arrested in their development by the atmosphere of the lofty regions of our globe. Smallpox, scarlatina, and other eruptive diseases, are unhappily developed with as much severity as in the neighbouring plains. In Mexico they still preserve the recollection of an epidemic scarlet-fever, which carried off, some years ago, a great many victims. Lastly, with regard to typhoid fever; though it appears, according to Dr Tschudi, to be rare among the Cordilleras, it is unfortunately not so among our own Alps, where it prevails at all elevations. As a proof of this we may mention the epidemic of 1839, which attacked a third part of the St Bernard monks, and caused many deaths in the surrounding valleys.

I might now conclude the series of facts illustrative of the influence of the climate of high mountains on the development of diseases, but as a close analogy exists between the pathology of the elevated regions of the globe, and of those situate at a moderate height, we shall proceed to consider the second part of our subject, before drawing from it any definite conclusions.

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* The figures placed within brackets after a name indicate the height in English feet.

§ 2. *The Physiological and Pathological influence of Alpine and Subalpine Climates (below* 6560 *feet).*

The preceding facts do not present so immediate a practical application as those on which I am now called upon to speak. In fact, with the exception of the Hospice of St Bernard, no permanent place of abode above 6560 feet exists in Europe, a circumstance which constitutes a striking difference between it and the various plateaux of Peru and Bolivia, which have made us acquainted with the influence of heights on the development of diseases.

We have to consider the same question, then, no longer in extreme positions, as has just been done, but in circumstances of ordinary occurrence, both in regard to permanent residence, and localities sought for by invalids.

Although the number of villages, hospices, or posting-stations met with in Europe, in places approaching to 6560 feet in height, is very inconsiderable, still there are a few, such as the Hospices of the Grimsel (7231), St Gothard (6808), the Simplon (6791); the station of Mount Cenis (6253), the Villages of Breuil (6585) at the foot of Mont Cervin; St Verin (6693) in the high Alps; and Maurin (6241) in the low Alps. But none of these localities are of any interest in a medical point of view; the case is different, however, with two establishments much resorted to by invalids, and which approach the foregoing in height, I mean the Righi (5906), and St Maurice (5860), in the Grisons, a village well known for its ferruginous springs.

The greater part of the high inhabited localities in the Alps and Pyrenees, many of which are made summer residences for a medical purpose, range between 3937 and 4921 feet in height. Lastly, between 1640 and 3280 feet, we find a great number of villages and establishments which may likewise be considered, though in a less degree, as presenting all the characters of mountain climates.

In tracing the modifications produced on the human body by the heights in question, it is particularly to localities about the height of 3280 feet that I wish my observations to apply, without neglecting, however, the information furnished by villages situate at a higher or lower level.

As we have already seen, the effects produced by a sojourn among mountains are either modifications produced in our different functions, and which ought, therefore, to be considered as purely physiological, or else they contribute to the development of diseases, and thus fall within the province of pathology. If we followed the order adopted in the preceding chapter, we should commence with the physiological influences; but as this is connected very intimately with the treatment of these diseases, it appears to me more natural to begin with the pathological influence; the more so, as the view of the most prevalent diseases among the inhabitants of alpine and subalpine climes, will very naturally complete the observations which have been made in the higher regions of our globe.

1. *Pathological Influence of Alpine and Subalpine Climates.*—In 1833, Dr Isensee expressed himself to the following effect:—"Morbi peculiares montium incolas, quantum tenemus, non afficiunt. Nec ullum de hac re libellum evolvere nobis quidem contigit."* This last remark is still as true as it was twenty-three years ago, for to my knowledge no particular work exists on alpestrine pathology, so that I could gain some precise notion of it only by referring to various isolated works on the diseases of certain mountainous regions, and availing myself of the kindness of such of my colleagues as were in circumstances to furnish me with valuable information on this subject.† If we can say with Dr Isensee, that there is no malady peculiar to the inhabitants of mountains, it is not less certain that various morbid affections are more frequently met with in such situations, while others more habitually fall to the lot of the inhabitants of the plain.

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* Elementa Novæ Geographiæ et Statistices Medicinalis, 8vo, Berolini, p. 53.

† Dr Archibald Smith from Peru has written on the subject of the Diseases of the Andes in the "Edinburgh Medical and Surgical Journal," 1840–42.

Inflammatory fever, without any precise localization, such as we have described it, after Dr Tschudi, is not altogether unknown in other mountainous countries. We find it, in fact, pretty frequently in certain parts of our Alps, as, for example, at Briançon (4265), the most elevated town in Europe. Dr Albert writes to me regarding it as follows :—" Inflammatory fever, without localization, and terminating in sweatings, loaded urine, and a slight eruption on the lips, is exceedingly common ; there is scarcely any one who has not had it oftener than once in his life." The frequency of inflammatory diseases is very great at Chamounix (3450), according to Dr Michon, who estimates them at more than the half of all those to which the inhabitants of this valley are subject.

A second point in alpestrine pathology, not less important, is the frequency of *hæmorrhages*, which show themselves, as might be anticipated, with less intensity and frequency than in the high valleys of Peru and Bolivia, but nevertheless much oftener in the alpine and subalpine regions than in the adjoining plains.

Among the hæmorrhages most frequently met with in the inhabitants of mountains, are hæmoptyses. They have been mentioned by Drs Cullen and Mansford as occurring in Scotland and England, as well as by Dr Flechner in reference to Styria.

In the valleys of Neufchâtel, which are about 3280 feet in height, the Genevese workmen are frequently seized with this disease, and it is also equally observed among the other classes of inhabitants. We find, indeed, by a note published by Dr de Pury, on the exemptions from military service in the Canton of Neufchâtel for 1849, that five or six times more persons were exempted, on account of hæmoptysis, in the mountainous parts of the valleys, than in the districts of Boudry and Neufchâtel, which are situate on the shores of the lake.

With regard to other kinds of hæmorrhages, some of them appear to be rarer among the mountains than in the plains ; such is the case with uterine bleedings, whether considered after childbirth or in any other circumstances. Dr Michon has met with only five cases of uterine hæmorrhage during the fourteen years of his practice at Chamounix. Of this number, three were owing to the insertion of the placenta in the neck of the uterus, and two were in consequence of the critical age. Is not this an evident confirmation of what has been said before ?

But it does not appear to me that there is any contradiction between the frequency of hæmorrhages in general, especially such as may be called active, and the rarity of uterine bleedings in mountainous countries, since the greater part of the latter may be considered as caused or promoted by a state of weakness ; on the contrary, if this remark be generalized, we may conclude, from what has previously been said, that active hæmorrhages are favoured by the tonic action of mountain air, while the same influence will act in an inverse manner in the case of passive hæmorrhages.

Diseases of the nervous centres are rather rare in mountainous countries. This conclusion results from the observations of Dr Albert in the neighbourhood of Briançon, and of Professor Lebert in the valley of the Rhone. Both of them have specified to me epilepsy, apoplexy, and simple or tuberculous meningitis, as being rarely met with in the mountainous countries just named. This establishes a considerable difference between the facts described by Dr Tschudi and those of which we are now speaking. Indeed, I have been unable to find in Europe any observation of cases at all approaching to those terrible cerebral inflammations which carry off such numbers in the high valleys of Peru and Bolivia.

With regard to *diseases of the respiratory organs,* we have mentioned the frequency of bronchitis, pleurisies, and pneumonias, as well as the rarity of phthisis pulmonalis in the countries just named. Let us now consider the effect of alpine and subalpine climates in this point of view.

And, on entering upon the subject, we may mention the opinion which has prevailed from ancient times, and which we find again brought forward in all works on hygiène and pathology, as to the frequency of inflammatory diseases of the lungs *in dry and elevated situations.* But we prefer direct observation to an opinion which may be merely traditionary, and have no foundation in fact. The following is the result of my investigations on this subject.

The first observation I shall make on the frequency of pulmonary inflammations is, that it increases with the elevation. This remark had been made in Germany by Dr Fuchs; and I am able to confirm it by the facts observed in the Alps of Dauphiny and Savoy.

On comparing the deaths caused by pulmonary inflammations in three different localities in Thuringia, Dr Fuchs has found the following proportions;—in the most elevated, at 2772 feet, a mortality of *sixty-seven* per cent; in a medium height, of 1919 feet, *sixty-two* per cent; and lastly, in the lowest locality, at 1598 feet, the mortality from pulmonary inflammation did not exceed *fifty-two* per cent.*

Similar observations have been made by the same author among the Harz mountains, and in some of the cantons of Switzerland, such as those of Uri and the Grisons. The three most elevated localities respecting which I possess documents, are Mont Cenis (6253), the Grande-Chartreuse (4613), the town of Briançon (4285), and Chamounix (3451).

The French soldiers who sojourned on Mont Cenis in 1796, from the 15th December to the 15th of May, were affected in great numbers with pneumonia, which formed the *fourth part* of the diseases observed at that period. †

According to the manuscript observations communicated by Professor Bertrand of Grenoble, it appears that the monks of the Grande-Chartreuse (4613), in the department of the Isère, are frequently attacked with pulmonary inflammations, particularly such of them as are called upon to engage in active duties. The new arrivals are affected with catarrh and momentary loss of voice.

Dr Albert, who has practised medicine for seventeen years at Briançon (4285), and in the villages on the neighbouring heights, writes to me that the diseases which he is usually called upon to treat are inflammations, and that the most frequent diseases of that nature are those of the air-passages, particularly bronchitis and pneumonia; it is to the latter that the greater number of the deaths of adult men are owing. Dr Michon, who has resided fourteen years in the valley of Chamounix (3451), informs me that cases of pneumonia form the *fifth part* of the diseases of the inhabitants of these regions.

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* Mediziniche Geographie. Berlin, 1853.

† Griselle, Traité de la Pneumonie, 8vo. Paris, 1846, p. 135.

At less considerable heights we still find a great number of inflammatory diseases of the lungs. This has been observed by Dr Grifoulière in reference to the mountains of Auvergne; he has pointed out the much greater frequency of affections of this nature in the elevated localities of Auvergne when compared with adjacent plains.* Similar observations have been made by Dr Koch in Wurtemberg,† and by Dr Flechner in Styria. ‡

Professor Savoyen of Moutiers writes me, that peripneumonias occupy the first rank among the diseases which attack the inhabitants of the Tarentaise Mountains.

Observations of a like nature have been communicated to me by many medical men who practise in the mountainous districts of the Jura, Savoy, and the valleys of Neufchâtel, where our countrymen, as well as other classes of inhabitants, are frequently seized with bronchitis or catarrhal affections.

Pulmonary inflammations sometimes develop themselves in an epidemic manner in the elevated parts of Switzerland, and commit great ravages among the inhabitants of the smaller cantons. This disease, which is known by the name of *Alpenstich*, was first described by Conrad Gesner in 1564, when it carried off a great number of the inhabitants. Since that time it has often ravaged Switzerland, and has been observed in recent times (1833) by Professor Schönlein, in the valley of Urseren, and in 1829, in the valley of Entremont, by Professor Lebert. According to these observers, the *Alpen-*

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* Gazette Medicale de Paris, 1833. p. 473.

† Monatschrift für Medizin, Von Ammon. Leipzig, 1836.

‡ Allgemeines Repertorium der Medizinischen Jahrbücher; November, 1841, p. 162.

stich is sometimes a pleurisy, at other times a pleuro-pneumonia, accompanied with typhoid symptoms, running its course very rapidly, and attended with great danger. It may be compared to the pluro-pneumonia of Peru, of which we have given an account from Dr Tschudi.

Pulmonary catarrh appears likewise to be more frequent in high grounds than in the plains; such, at least, is the opinion of most of the authors and practitioners I have had it in my power to consult on the subject. But this is not the case with influenza or epidemic pulmonary catarrh, which, according to the observations of Professor Lebert, appeared not to visit the mountainous regions of Bex and St Maurice when he practised in that neighbourhood. If this exemption from influenza should be verified, we may find the cause of it in the coolness and dryness of the air, qualities unfavourable to the development of epidemic pulmonary catarrh. I remember, indeed, that when this disorder appeared at Geneva with unusual severity, in the winter of 1834, there was not a single family without one or more invalids, and their number increased every day as long as the south wind continued, and the torrents of rain which accompanied it. But when the north wind began to blow, and a dry cold succeeded the humidity, the number of the sick diminished so rapidly, that in a few days the epidemic was almost completely arrested by this atmospheric change.

Among the documents which I have collected on the subject before us, there are two which I wish to mention, as being in some respects contradictory of those I have quoted. The first contains the facts observed in 1837 and 1839, in the canton of Zurich, by Dr Locher-Balber, from which it appears that pneumonias and pulmonary catarrhs were twice more frequent in the plain than in mountainous districts. Have similar observations been made at other periods? This we are unable to say, for we have nothing either to confirm or refute the statement of the Zurich doctor.*

The second document I wish to refer to, was communicated to me by Professor Lebert, who has observed, during a residence in the neighbourhood of Bex (Vaud) and St Maurice (Valais), that pulmonary catarrhs were much less frequent in the mountain villages than in the plain; with regard to pleurisies, the case was rather the reverse; and lastly, he found no difference between these different localities in reference to pneumonia.

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* Schweizerische Zeitschrift für Natur und Heilkunde, 1841.

I have no wish to disguise the importance of these two series of observations; but if we remark, on the one hand, that Professor Lebert found no predominance of pneumonia in the plains over the mountains, and, on the other hand, that pleurisy has occurred to him most frequently on heights, we will perceive that the affirmations of the Zurich professor are not very precise; and if we add to this the remark that, with the exception of the two authors named, all others are unanimous as to the much greater frequency of pulmonary inflammations bronchitis, pneumonias, and pleurisies, in mountainous countries; we shall be led to consider the last opinion as best founded, since it rests on facts observed in very different localities, such as the Alps of Piedmont, Savoy, Dauphiny, and Switzerland, as well as the heights of the Jura, Auvergne, Wurtemberg, the Harz, Thuringia, and Styria.

Is *phthisis pulmonalis* rare or frequent among the inhabitants of mountains? Such is the question we are now called on to answer, and to which I wish for a short time to draw the attention of my readers.

Dr Fuchs has published, in his Medical Geography, a series of statistical tables, by which he is led to affirm, that "phthisis pulmonalis becomes rarer as the country becomes more elevated."* Let us inquire whether the documents I have collected on this subject confirm the assertion of the doctor of Botterode.

It has been stated above, that, in the elevated regions of Peru and Bolivia, phthisis was almost entirely unknown, and that the few who fell victims to it were Creoles, the descendants of Europeans, who may have carried along with them the germs of a disease which never attacks the Indians, the ancient inhabitants of the country.

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* Op. Cit., p. 35.

With regard to Europe, I have found no mention of phthisis pulmonalis among the diseases which afflict the inhabitants of the most elevated of our Alps, such as St Bernard or the Grande-Chartreuse. In reference to Briançon, Dr Albert writes me, that circumstances of wretchedness or excess, altogether exceptional, are necessary to develop any one of the tubercular disorders which are so common in the lower valleys of the Alps.

Observations to the same effect have been made at Chamounix by Dr Michon; among the Tarantaise Mountains, by Dr Savoyen; among those of Styria, by Dr Flechner; and of the valley of the Rhone, by Professor Lebert. These practitioners agree in declaring that phthisis pulmonalis is more frequent in low and flat countries than on the surrounding high grounds. One of them, Dr Flechner, refers on this occasion to the popular opinion as to the antagonism supposed to exist between goitre and tubercle; so that where the one is frequent the other rarely occurs. Not being at present in a condition to decide on this theory of exclusion, I content myself with stating the fact, that in a great number of lofty localities phthisis pulmonalis is either unknown or excessively rare, which confirms the opinion of Dr Fuchs as to the freedom of heights from the malady in question. But if the preceding facts favour this conclusion, there are others, which must not be passed over in silence, which are altogether opposed to it.

In 1818, Dr Mansford published a work with the intention of showing that in England cases of phthisis were more numerous in proportion as the residence of the inhabitants was elevated above the level of the sea;* a proposition diametrically opposed to that of Dr Fuchs, and yet supported by statistical authorities which appear to me not a little conclusive.

On the other hand, we find in the Memoir of Dr Locher-Balber, already mentioned, a positive confirmation of Dr

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* An Inquiry into the Influence of Situation on Pulmonary Consumption. 8vo. London, 1818.

Mansford's observations, in the fact that tubercular diseases were found, in 1837 and 1839, doubly frequent in the mountainous districts of the canton of Zurich, compared with what they were on the banks of the lake.

On adding a few unpublished documents to the preceding, we find in them the confirmation of the opinion which has just been expressed. In fact, nothing equals the frequency of phthisis pulmonalis in the greater part of the Alpestrine valleys of our neighbourhood. Whether we traverse the Jura, ascend the course of the Arve, or repair to the mountains of Bornes and the environs of the lake of Annecy, we encounter, in all of these localities, a very considerable number of phthisical cases. The majority of the patients who came to consult me, or whom I have visited in the regions in question, were tuberculous. Astonished at the prevalence of this species of malady, I have questioned both medical men and the inhabitants, and I have invariably come to the same conclusion. Sometimes it was a patient dying of consumption, and of whom it was told me that, although still young, he was the only survivor of his family or contemporaries; sometimes it was a young man, robust to appearance, and in whom, notwithstanding, the malady had commenced to which seven or eight brothers had already fallen victims. Such facts came under my notice on numerous occasions, during the course of a practice which now extends over more than a quarter of a century.

Thus, then, we cannot hesitate to admit that phthisis pulmonalis is met with very frequently in certain mountainous regions. But how can this conclusion agree with those of Dr Fuchs? It does not, however, appear to me impossible. In truth, the majority of the facts which prove the rarity of diseases of the lungs on high situations have been observed in the very elevated regions of Peru, Bolivia, and the high Alps, while almost all the other observations refer, it is true, to mountainous localities, but situated at very inconsiderable heights—such as the English towns mentioned by Dr Mansford, the hills and mountains surrounding the lake of Zurich, and lastly, most of the valleys of the Jura, Samoëns, Sixt, and the Bornes.

We are now, therefore, in a condition to conclude, with a considerable degree of certainty, that if the low valleys or medium regions of our Alps present a great number of phthisical cases, this disease becomes rarer and rarer as we ascend, in so much that, at a height above 3280 feet we meet only with a few isolated cases, and at 4920 feet pulmonary phthisis entirely disappears. This phthisical zone, above and below which this disorder disappears, may be approximately fixed at between 1640 and 3280 feet.

We shall afterwards see that tubercular diseases are not the only ones which develop themselves within certain limits of height; scrofula, goitre, and cretinism, are likewise very general in the lower valleys and the mountainous regions of our Alps, but beyond a certain height these three diseases entirely disappear. In consequence of this we are constrained to admit that certain anti-hygienic conditions, to which we shall have occasion again to revert, perform a more important part than the atmosphere of mountains in the development of tubercular diseases, as well as of the other morbid affections we have enumerated.

While phthisis disappears at a certain height, we find on the contrary, that *asthma* increases, both in frequency and severity, as we ascend above the level of the sea; a circumstance which has procured for this disorder the name of *asthma montanum*. We have already seen how much the respiration is injured in the high regions of the globe, and how a permanent residence at St Bernard infallibly induces a diseased condition of it. Similar remarks have been made in reference to less considerable heights, such as Chamounix, the Grande-Chartreuse, and the mountains of Styria, by Dr Flechner;* those of the Harz, by Dr Brokman;† of Thuringia, by Dr Fuchs,‡ and the environs of Zurich, by Dr Locher-Balber.§ Lastly, by examining the statistical tables published by order of the Sardinian Government, we ascertain that the number of asthmatic patients exempted from military service, is much more considerable in the mountainous regions than in the plains of Piedmont.* The same predominance of asthma has been noticed in the mountains of Neufchâtel, compared with the districts on a level with the lake, as regards exemption from military service.† We are thus fully authorized to consider pulmonary emphysema, along with its ordinary consequences of asthma, chronic bronchitis, and liability to be affected by atmospheric changes, as a natural consequence of residence on heights, and as manifesting themselves with greater intensity as the level is elevated above the sea.

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* Op. Cit.

† Die Metallurgischen Krankheiten des Ober-Harzes, 8vo. Osterode, 1852.

‡ Op. Cit. § Op. Cit.

Cases of *chronic bronchitis* are more frequent in mountainous countries than in the adjacent plains, as we are entitled to affirm from the observations of Professor Lebert in the Valley of the Rhone, of Professor Bertrand among the Alps of Dauphiny, and of Dr Brockman in the chain of the Harz.

Organic diseases of the heart are likewise met with more frequently in the same circumstances, as has been observed by Dr Flechner in Styria, and Dr Brockman among the inhabitants of the Harz. The same result may be deduced from observations collected in the canton of Neufchâtel, where nearly twice the number of exemptions from military service are occasioned by hypertrophy of the heart in the mountainous regions than in the districts bordering on the lake.

The preceding facts, therefore, cause us to regard mountain climates as favourable to the development of diseases of the heart, not only on account of the acceleration of the circulation, under the influence of continual walking up steep ascents, but also in consequence of the rarefied atmosphere, which must tend to disturb the central organ of circulation more or less seriously.

The influence of diminished atmospheric pressure might lead us to suppose that *varices* would be more frequent among mountains than in the plain. But observation does not confirm this supposition. It follows, in fact, from the investigations of Dr de la Harpe, of Lausanne,‡ that varices are much rarer in the mountainous districts than in the lower regions of the Canton de Vaud. It even appears, that, for a period of fourteen years, there has not been a single exemption from military service on account of varices among the inhabitants of the Lake of Joux, which is situate between 3280 and 4265 feet above the sea level.

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* Rendiconts. † Manuscript already quoted.

‡ Quelques mots sur les causes probables des varices chez l'homme. Zurich, 1856.

Diseases of the digestive organs are rather rare among the inhabitants of mountains. The only kinds met with, in any degree of frequency, are diarrhœas and dysenteries in the autumn; still they are not so severe as in the plains. It is particularly in the torrid zone that we observe this favourable influence of mountain air in preventing or curing dysentery and other disorders of the digestive canal, which are the cause of so many deaths in plains and on the sea coasts. Mountainous regions are not, however, entirely exempt from disorders of this nature; for dysentery has been observed at a height of 6560 feet under the tropics, and at 2296 feet among the mountains of Switzerland. About half a century ago, it appeared in an epidemic form in Thuringia, at a height of 1312 or 1640 feet; but it has not since revisited these regions.

In short, it may be said that morbid affections of the digestion are infinitely rarer, and much less severe, on high grounds than in the plains. The same remark applies to organic diseases of the liver and stomach.

The *functions of the uterus* are frequently modified under the influence of mountain climates. Chlorosis is frequently met with, as well as leucorrhœa and various irregularities of menstruation. But, as has been already stated, uterine hæmorrhages are rare, either after childbirth, or in any other circumstances.

Although *intermittent fever* is rather a disease of low, damp, and marshy countries, still high situations are not entirely a protection against it. According to Dr Fuchs, it is observed in Mexico up to a height of 6560 feet.* And among our own Alps it is not a rare thing to observe it at an almost equal elevation. Professor Lebert has had the charge of cases at 6223 feet at the Chalets of Anzeindaz (Vaud), and at 4052 feet in the Hamlet of Posses (Vaud), although there were no marshes in the neighbourhood to account for its appearance.

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* Op. cit., p. 64.

Setting aside extreme cases, and keeping in mind the observations made in different latitudes, it may be affirmed that "The frequency and severity of intermittent fever decrease with the height." It thus appears that the practice almost universal in marshy countries, of leaving the plain and repairing to the mountains, in order to escape from, or to cure, intermittent fever, is founded on a correct observation of facts.

It may be added, however, that, in some cases, marsh miasm may be conveyed by the fogs which rise from marshy plains to the neighbouring heights, so that we may partly ascribe the fevers observed among mountains to the marshes situated at their foot. If this last supposition be correct, we may be justified by it in considering mountainous countries as almost completely exempt from intermittent fevers, save in the few exceptional cases which have just been mentioned.

We have seen that, notwithstanding the existence of atmospheric conditions, which seem calculated to favour the development of *rheumatic diseases*, this class of maladies is almost wholly unknown in the high mountains of Peru and *Bolivia*. This is, unfortunately, not the case in Europe; in fact, to whatever height we ascend, we encounter the various forms of this complaint. Whether we select as our field of observation the vicinity of Briançon, above 6265 feet, or the heights adjoining Diablerets and the Dent du Midi, or traverse the mountains of Styria or the Harz, we shall everywhere find muscular, neuralgic, or articular rheumatisms. And with regard to the greater or less frequency of these various forms of the disease, different observers are unanimous in declaring that lumbago, torticollis, and sciatica, are much more general among mountaineers than among the inhabitants of plains, while the opposite is the case with articular rheumatism, whether acute or chronic. In confirmation of this last opinion, I may select a single example from many of the same kind. The exemptions from military service on account of rheumatism, have been six times more numerous in the districts adjoining the Lake of Neufchâtel than in the mountainous quarters of the same canton.

Eruptive complaints are as frequent on high grounds as on plains, as we have already remarked, when speaking of Alpestrine climates. Scarlatina, measles, and smallpox, appear in greater intensity wherever they find circumstances tending to promote contagion; perhaps, even in spite of the purity of the air, these diseases are so much the more severe and widely spread, as the dwellings in the high Alps are confined and unhealthy. This latter remark may explain, in a certain degree, the frequency of *typhoid fever* in the majority of elevated localities, where we observe this disease propagated and reproduced every year with the greatest facility. This has been shown to be the case by Professor Lebert in Switzerland, Professor Bertrand on the heights around Grenoble, and practitioners in the Vaudese valleys of Piedmont.

There are still three diseases on which I wish to make some remarks; scrofula, goitre, and cretinism.

Scrofulous diseases are not rare in mountainous countries. But are they more frequent than in the plain? This is a question which I do not hesitate to answer in the affirmative. It appears, indeed, to be unquestionable, from the investigations of Professor Lebert respecting the scrofulous patients of the different districts of the Canton de Vaud, that mountainous regions are more frequently attacked with diseases of this kind. My own personal experience entirely agrees with that of my honourable colleague. In fact, the greater number of the scrofulous patients placed under my care came originally from the declivities of the Jura, or the Alpine regions of Savoy.

Must we suppose, from these facts, that mountain climates are favourable to the development of scrofulous complaints? Before coming to such a conclusion, we must take into account the less easy circumstances, the inferior food, the frequent intermarriages between members of the same family, and the general neglect of the laws of health in building dwelling-houses, and compare all these circumstances with such as surround the inhabitants of towns, where incomes are larger, food more plentiful, ease and comfort more generally diffused. It is necessary, also, to consider the stagnation of the air and humidity of the atmosphere in the deep valleys of the Alps, into which the sun can penetrate only a few hours a day. All these considerations combined are more than sufficient to explain the predominance of scrofula in mountain residents, apart from questions concerning climate. Is the case the same in villages with a good exposure, and whose inhabitants are in somewhat easy circumstances? I think not. On the contrary, it appears to me extremely probable, that where hygienic circumstances are favourable, scrofulous diseases are rarer in the mountains than in the plains. We shall find a confirmation of this view in what remains to be said on goitre and cretinism, diseases which have a close analogy to scrofula.

In most of the valleys of the high Alps we meet with *goitrous* persons and *cretins*. In producing these diseases, what is the influence of climate and of the anti-sanitary circumstances which we have enumerated in regard to scrofula? This we shall not be in a condition to determine for some time to come; but, in the meantime, thanks to the investigations of the Sardinian government, and the numerous works of Swiss and German physicians, we can no longer doubt the fact, that if the woods be cleared away around the villages, the dwellings improved, and, at the same time, the inhabitants placed in easier circumstances, and causes of disease thus removed by a more judicious application of the laws of health, we do not fail to find goitre and cretinism diminish, and even disappear. And if we add to this consideration the fact about to be mentioned, namely, that neither goitres nor cretins are met with beyond a certain limit of height, we shall become more and more convinced of the correctness of this conclusion. In the mountains of Thuringia and of the Black Forest, cretins disappear above 2296 feet. Among the Alps, the absence of cretinism manifests itself at about 2952 feet in northern exposures, and at 5577 feet in southern exposures. Cretins are not met with in the Cordilleras above 14,100 feet.

The inhabitants of countries liable to this infirmity have long been aware of this privileged condition of high grounds, and of the beneficial properties of the invigorating air breathed there, for preventing or ameliorating the physical and intellectual state of children predisposed to cretinism. It is with this view that they send women to be delivered, and their children to reside for a time on heights. It is also on this popular opinion that the experiment has been founded, carried on for twenty years by Dr Guggenbuhl, at Abendberg (3624). Convinced that the high strata of the atmosphere exert a preventive influence on the development of cretinism, this philanthropist was the first to conceive the happy idea of employing this means of counteracting the malady and arresting its development. It is not for me to give a decided opinion, in this place, as to the extent of the results obtained by his method; but, from the facts which have come under my own personal knowledge, it appears that a certain number of cretins and idiots leave this establishment in a physical and intellectual state so considerably improved, that we must admit, with Dr Guggenbuhl, that much of the change may be ascribed to the atmosphere of the high mountains, which not only prevents the appearance of cretinism, but arrests its progress when it has already appeared under the influence of those anti-hygienic causes enumerated above.

Let us now give a short recapitulation of the preceding facts, and thus trace the main features of what I call *Alpestrine pathology.*

We have seen, in the first place, that there are three principal diseases which increase, both in frequency and severity, with the height,—inflammation, asthma, and hæmorrhages.

In the second place, we have ascertained that there are other morbid affections which develop themselves between the limits of a certain range of elevation in such a way that they are rare or unknown above and below these limits. We have fixed, approximately, the phthisical zone between 1640 and 3280 feet; that of goitre and cretinism at heights varying according to the exposure and latitude; and finally, the zone of scrofulas, which has many relations with that of phthisis.

In the third place, we have indicated the comparative frequency of diseases of the heart, chronic bronchitis, muscular or neuralgic rheumatisms, and chlorosis, in mountainous countries; while intermittent fevers, disorders of the digestive canal, articular rheumatisms acute and chronic, as well as uterine hæmorrhages, are met with there more rarely than in the plain.

Lastly, we have ascertained that there are certain morbid affections which appear to be in no respect modified by height. Typhoid and eruptive fevers are of this class.

Such are the results which arise from the investigations I have undertaken on this subject, hitherto so little studied, and which I hope will be of future advantage. In the meantime this view, although very incomplete, of the pathological influence of heights, may furnish some valuable indications to medical men to guide them in the advice they are called upon to give as to the diseases which may be successfully combated by a mountain residence. But before entering upon the practical department of our subject, we require to ascertain, from direct observation, what physiological modifications are produced on our organs by alpine and sub-alpine climates.

§ 2. *Physiological influence of Alpine and Sub-alpine Climates (below 6560 feet).*

We have seen what diseases develop themselves in the native inhabitants of mountains; let us now consider the changes which take place in our organs under the influence of a temporary abode in the same regions.

When the locality chosen for a residence does not surpass 3230 or 4921 feet, none of those serious disturbances usually take place in the respiration and circulation which are observed at greater heights. It seems, on the contrary, that notwithstanding the decrease of atmospheric pressure, these functions are performed with greater ease and regularity.

The respiration becomes fuller and more complete, as if a considerable weight had been removed from the walls of the thorax. This sensation of wellbeing is expressed by the word *lightness*, applied to the air of mountains compared with that of the surrounding plains, which is designated by the opposite terms *heavy* or *stifling*.

The circulation likewise yields in a perceptible manner to the influence of moderate elevations; the pulse becomes calmer and more regular; a just equilibrium is established between the venous and arterial circulation, so that persons predisposed to congestions soon feel themselves greatly relieved after sojourning some time in a lofty locality. It is true that under the influence of a more complete respiration, as well as in consequence of a more active assimilation, a state of plethora frequently supervenes, and this, concurring with a weak atmospheric pressure, may bring on hæmorrhages; a circumstance which deserves serious consideration when it is contemplated to send to an elevated situation a patient predisposed to this kind of morbid affection.

Another effect, not less characteristic of climates of this description, is the activity they infuse into the muscular system. Nothing is more striking than the rapidity with which patients in a state of the utmost debility recover on high grounds the strength which they had believed to have been lost beyond recal. While, in the plains, a walk of a few minutes was sufficient to bring on intolerable fatigue, transported to the invigorating atmosphere of the Alps, they can spend with impunity many hours in roaming about them. The sensations, so novel in their character, which they then experience, find utterance in figurative expressions. Sometimes it is a cuirass which supports and encloses them on all sides, imparting a strength which seems inexhaustible; sometimes it is a facility of motion so great that they feel as if borne up above the earth. Accordingly, we often see frail and delicate beings, who in their ordinary mode of life calculate every movement, in order to avoid a fatigue disproportionate to their strength, yet who, when once they have reached the heights, are able to climb the steepest hills and undertake lengthened walks, drawn on by the wish to contemplate some beautiful view, or to gather some alpine flower to adorn their album.

Lastly, to conclude this view of the influence of heights on the muscular system, we may mention the rapidity with which the strength is recovered when it seems exhausted by long walking. This was often experienced by Saussure; and he describes it in the following manner: " The strength is repaired as speedily (and to all appearance as completely) as it has been exhausted. Merely a cessation of movement for the short space of three or four minutes, even without seating one's self, seems to restore the strength so perfectly, that on resuming progress, one feels as if able to climb at a single stretch to the very peak of the mountain. But in the plain, fatigue like this could not be overcome with so much ease."

The digestive functions are also considerably modified; the appetite becomes more active and regular; its cravings are more frequently felt, and it becomes necessary either to lessen the interval between meals, or to indulge in them more liberally. The kind of food may likewise be varied; for as the stomach bears a greater quantity, it also digests more easily substances which, in the plain, would occasion pain and indigestion.

But it is not merely the muscular strength, the respiration, and digestion, which are modified by the mountain atmosphere, it is more especially the nervous system on which it acts with greatest power. How many persons, enfeebled by too intellectual a life, have recovered, by this means, the power of thinking, and devoting themselves anew to the labours of the study? How many others, worn out with cares and anxieties, have recovered the tranquillity and equipoise of mind necessary to enter with success into active life? Others have found that excessive sensibility and cerebral excitement which renders the will powerless in moderating the tumult of the thoughts, gradually give way to its influence.

These are not the only respects in which the good effects of mountain air are observable; what contributes particularly to the restoration of health is the change it produces in regard to sleep. Persons accustomed to sleep heavily, dreaming much, and awakening almost as fatigued as when they went to bed, feel a great improvement in this respect; the sleep becomes tranquil and refreshing, and the entire constitution, as well as the nervous system, receive from it a salutary impression.

This effect of heights in rendering sleep lighter may sometimes produce sleeplessness in very impressible individuals, but it is seldom that this symptom continues beyond a certain time. When it happens to be otherwise, it is necessary to leave a residence found to be too exciting.

It is probably also in consequence of some modification of the nervous system that the atmosphere of mountains causes a very different state of feeling from that of the plain. At the same temperature, cold is much less felt on the heights, and occasions no disagreeable impression, thus permitting a longer stay in the open air, without any apprehension of bad consequences, even in the most delicate persons.

We may therefore conclude, by way of recapitulating the preceding facts, that if the respiration be freer, the circulation more regular, and the digestion more active, it is evident that it is by modifying the functions of assimilation and sanguification (hematosis), that the air of heights gives a new life to debilitated constitutions; and, on the other hand, that if the muscular vigour be increased, the sleep more tranquil, and the intellectual functions calmer, it is because the air of mountains exercises a twofold action on the nervous system—sedative as regards the brain, and stimulating in respect to the functions depending on the nervous centres, the spinal marrow, and the ganglions. It thus definitely appears that, when we wish to render nutrition more complete, and re-establish the equilibrium between the animal and mental functions, we should recommend a sojourn in some elevated locality; while we should carefully avoid the use of exciting therapeutic agents, whenever we have to do with plethoric persons, disposed to inflammations or hæmorrhages, and who are excessively nervous, or labouring under some organic disease accompanied with fever or great vascular irritability.

Let us now apply the results of our investigations to medical practice, and take a review of the different diseases on which the air of mountains may exercise a favourable or unfavourable influence.

III. *What are the Diseases which may be mitigated or made worse by a sojourn among Mountains?*

The atmosphere of heights exercises, as we have seen, a special stimulating action on the digestive functions; it is not surprising, therefore, that stomachs weakened by a too sedentary life, or injured by bad treatment, should derive benefit from a mountain residence. We frequently see invalids seized with gastralgia or dyspepsia in various degrees;

hypochondriacs with a sluggish and slow digestion; all *who feel their stomachs*, to use the expressive remark of a lady of my acquaintance, who indicated her state of perfect health by saying that she did *not feel any part of her body;* all patients who experience during digestion, heaviness, acidity, flatulence, or pains; to all such nothing can equal the invigorating action of high places, which not only restore the appetite, but render digestion easy and rapid.

I have myself had experience of this, by a residence of this kind after a bilious fever which had in some measure paralyzed my digestive powers. I had scarcely spent a few days at Mornex,* when my appetite and the power of digestion were re-established.

But there are two difficulties against which it is necessary to be on our guard; the first is the disproportion which often exists between the digestive power and the desire for food, the last being often so urgent that one would be tempted to indulge it, if great prudence be not used with regard to the quantity of food. The second evil against which it is necessary to guard, is the constipation which often comes on in high grounds, both in consequence of a more complete assimilation, and as the result of a peculiar influence on the peristaltic motions. This tendency must be speedily counteracted, as it cannot fail, combined with a more substantial nourishment, to bring on some gastric or intestinal derangement.

It naturally results from what has been said, that diarrhœas dependent on a state of weakness, or not induced by any organic cause, will be mitigated by an abode of this nature, provided always the precautions just spoken of be attended to. When the intestinal flux is produced or kept up by ulcerations or some disease of the liver, not much is to be expected from a mountain residence, except, perhaps, its giving some strength to a broken constitution, and thus resisting the ordinary consequences of an incurable malady.

We have seen that the atmosphere of high grounds exercises a powerful influence on hematosis, that the respiration is fuller, and the circulation more regular; it will therefore be understood that all classes of patients or convalescents in whom the blood is impoverished, either from primary or secondary causes, ought to derive from it a speedy improvement.

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* Highest part of the village, 1857 feet; Bellevue Hotel, 1801 feet; Chapuis Hotel, 1630 feet.

Experience in this case is in perfect harmony with theoretical inductions. In fact, convalescents who have been subjected to a lengthened regimen, long confinement, or an energetic antiphlogistic treatment, almost always find themselves improved on leaving the plain.

The case is the same with those suffering from chlorosis and anæmia, who speedily regain strength and colour under the same influence. We cannot insist too much on the benefit which this class of patients may obtain, such of them especially as have not been benefited by the use of iron and skilful treatment. This is likewise the case with chlorosis accompanied with cough and fever, which has so great a resemblance to acute phthisis, that the most careful practitioners are often deceived by it; nothing can equal the effect of heights in removing the cough as well as the fever, in restoring the appetite, and re-establishing the health.*

The same remark applies with still greater force to persons enfeebled by a long residence in warm countries. If they are merely debilitated by tropical climates, or seized with anæmia, in consequence of chronic hepatitis or frequent attacks of dysentery, I am unacquainted with any therapeutic resource for counteracting these morbid states comparable to the invigorating air of the Alps; and more than one patient can tell of the happy change it has wrought in them. What we can affirm in this respect of the mountains of Switzerland, the inhabitants of India and Africa can say of the Neilgherries and the Himalaya, and the heights which overlook the western coast of Africa, which would be the tomb of a much greater number of Europeans, without the valuable resource of mountain air, which preserves from pestilential effluvia, and imparts some vigour to constitutions exhausted by the heats of these inhospitable countries.

Finally, there is another form of chloro-anæmia which is likewise very notably mitigated by high grounds, I mean that which results from frequent attacks of intermittent fever. Such a situation presents the double advantage of changing an air charged with deleterious effluvia for one essentially tonic, which exerts the most favourable influence on marsh anæmia, whether it be accompanied or not with anasarca and obstructions of the spleen.

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* See Dr Rilliet's Memoir on this subject. (*Archives de Medecine*, February 1855).

In cases of dropsy, caused by some internal disease, not much advantage can be expected from such a change of air, but rather the contrary; for the activity imparted to the circulation and assimilation, as well as the almost absolute impossibility of walking without going up hill, are at variance with the action of the therapeutic remedies required for this disease.

It is the same with confirmed phthisical cases, as the disorder advances with greater rapidity on high grounds than in the plain. The apprehension of hæmoptysis is another reason for preventing us sending to the mountains such as are threatened with phthisis. But when there is no hectic fever, and the tubercles are not far advanced, it is not rare to find the malady checked by sojourning in an elevated locality, provided it be exposed to the east or south. The experience of the medical men of Geneva is unanimous in admitting that the air of Mornex (1630 to 1856) unites in the highest degree the qualities indicated above; and that it exercises an eminently beneficial influence on diseases of the chest not far advanced, by allowing a certain amount of exercise and abode in the open air. Some villages situated on the hills which overlook Mornex appear to enjoy the same advantage.

The various forms of asthma and pulmonary emphysema, present very different results on heights; some of them are very considerably mitigated, so that the patients almost escape the oppressive paroxysms, and can take exercise and food without injury. There are even some of them who cannot breathe freely except on the mountains, and experience a sense of suffocation when they descend to the plain. But the contrary is observed in the greatest number; they suffer the more the higher the level above the sea. In all asthmatic patients, fine weather relieves the respiration, while humidity renders it difficult, and this remark particularly applies to alpestrine localities, where this class of patients ought never to remain after the weather becomes cold and damp.

Among the other disorders of the respiratory apparatus which are benefited by heights we may enumerate chronic pulmonary catarrhs, more especially when they do not depend on any organic disease of the heart. Those recovering from influenza or acute pulmonary catarrh are in the same condition, as well as patients suffering under hooping-cough. With regard to the latter, when the first month is over, nothing can effect a greater improvement than this remedy, provided, however, the place chosen as a temporary station have a good exposure, and combine the qualities we have ascribed to the climate of Mornex, which is justly regarded as highly favourable to this class of diseases. But it must not be forgotten with regard to this, as well as all thoracic complaints, that the air of mountains predisposes to inflammations, and that we ought to take into consideration this pathogenetic cause in a disease which so frequently becomes complicated with broncho-pneumonia.

We have seen that the muscular strength is greatly increased under the influence of which we are speaking; it will therefore be understood that all cases of paralysis, not connected with a state of cerebro-spinal congestion, ought to be benefited by this means. This is likewise observed in the weakness which so frequently complicates hysteria, as well as those which follow rheumatism in the joints, gout, and diseases of the spinal marrow. It is not rare, in the latter cases, to witness persons long confined to bed recover strength in a few days, and able to take pretty long walks without much fatigue.

But just as we have seen the appetite exceed the digestive powers, and require to be kept in check, so the same thing often happens with the muscular strength, which, under the excitement of a mountain atmosphere, sometimes appears to be more speedily and completely restored than it really is; hence often follows an excess of fatigue felt for a long ime afterwards, if the strength be pushed to the extreme limit of which it is thought capable. Accordingly, it is necessary to recommend great prudence, both with regard to the exercise taken on foot, and with respect to the amount of diet.

Diseases of the nervous system are also greatly relieved by an elevated residence. This is the case with hysteria and hypochondriasis in their different forms; with simple, (not rheumatic) neuralgia; megrims (hemicrania), which sometimes disappears suddenly on removing from the plain to the mountain; sleeplessness, which in the majority of cases soon yields to the same influence; finally, all the different forms of nervous fatigue, intellectual or cerebral, which, for the most part are favourably modified by the same means. With regard to chorea and epilepsy, they do not undergo from it any perceptible change.

The various irregularities of menstruation which have been mentioned above are among of disorders which appear to be in a manner quite peculiar, under the influence of the quality of the air. On heights, leucorrhœa is diminished; menstruation is more copious; while uterine discharges, which are increased by weakness, are very promptly and very remarkably mitigated.

With respect to other hæmorrhages, we have seen that the air of mountains aggravates them, when they depend on an excess of vitality or too active a circulation; but that, on the contrary, if they arise from a defect in the plasticity of the blood, there is no curative means equal to the vivifying influence of an elevated locality to restore the strength by putting an end to loss of blood in this way.

Hæmorrhoidal congestions become less frequent on heights, which assist the restoration of the equilibrium in the venous circulation. It is true that, under this influence, transitory congestions sometimes occur; but this crisis is rather favourable, and most frequently contributes to restore health and comfort to persons labouring under infirmities of this kind.

Finally, and to conclude this enumeration of cases which may be benefited by change of air, it may be affirmed, that of all who have been subjected to this influence none have undergone so rapid and complete an improvement as the diseases of children. Whether they be enfeebled by any acute or chronic morbid affection, or suffering from a state of diathesis, such as tubercles or scrofula, they seldom fail to recover strength and appetite; their colour becomes healthy, and that even in the space of a few days, which is for the most part sufficient to work such a change in these little patients as to make them scarcely recognisable.

And now that we have reviewed the various morbid affections which are modified by the atmosphere of heights, I have nothing more to do, in order to conclude this long investigation, than to make known the different localities which may be chosen, and point out the hygienic precautions requisite for obtaining all the benefit that may be expected from a therapeutic agent so valuable as that under consideration.

IV. *What are the Localities best adapted to different Diseases, and the Hygienic precautions necessary for a sojourn among the Mountains?*

Let us begin with making a few preliminary remarks on the circumstances calculated to favour success, and then take a review of the resources afforded by Switzerland and the neighbouring districts of Savoy, in order to accomplish the object indicated for this chapter.

The first remark, to which it appears to me of importance to attend, is, that it is necessary to proportion the height to the degree of sensibility of impression in the patients. Some of them are so truly sensitive in regard to change of air, that removal from the town to the country is sometimes sufficient to produce a considerable alteration in their state of health; it is not necessary, therefore, to go far, or to ascend high, in search of what may be found at the door.

Other persons are influenced by changes of height, apparently by no means considerable, but still sufficient to bring on a real transformation. For this class of patients, we may choose localities in the immediate neigbourhood of towns, and adapt them, in regard to height and exposure, to the susceptibility of impression and nature of the disorder we wish to remedy. We may apply these principles to some villages in the neighbourhood of Geneva, which, notwithstanding slight differences of level, possess very different atmospheric qualities. Similar observations have no doubt been made regarding other towns; but it is evident that I cannot enter into details of this nature without lengthening this memoir much beyond the limits assigned to me.

Let us now speak of the hygienic precautions necessary to derive the greatest benefit from an abode of this nature. The first and most indispensable is easy access, with a carriage road, and sufficient means of transport for conveyance thither, as well as for the exercise of convalescents or patients incapable of the fatigue of even a moderate walk. The second condition relates to lodgings, which ought to be comfortable, dry, well-aired, and admitting of being warmed, the latter being more necessary, as the changes of temperature are greater and more sudden. The third relates to diet, which ought to be substantial, varied, and suited to convalescents. One may carry with them supplies of tea, wine, or other secondary substances, if they wish to have them of superior quality. With respect to bread and flesh, the essential bases of all restorative alimentation, their good quality is of the highest importance if we wish to obtain full benefit.

The last two circumstances I wish to mention, are, the length of time to be spent among the mountains, and the season most suitable for the purpose; and I unite the two, as they are so intimately connected with the height of the locality selected as a residence. In fact, the higher the level, the more decidedly tonic and exciting are the qualities of the air: above 3937 or 4921 feet, therefore, the stay should not exceed six weeks or two months; while below 3280 feet, it may last without inconvenience for two or three months. It often happens that changes of place are necessary for success; because the body sometimes becomes very speedily habituated to the tonic air of heights, and the benefit gained at first will not fail to diminish unless we seek in a higher locality what we once found in a lower one. Sometimes, also, the excitement produced by this means exceeds proper limits, bringing on want of sleep, palpitations, frequency of pulse, or nervous agitation, when it becomes necessary to descend again to a milder climate.

With respect to the most favourable season, that depends, first on the height, secondly on the exposure. When the latter is to the south or east, and the height not great, as, for example, from 1968 to 2624 feet, one may leave the plain in the month of April or May; to places about 3280 feet, whatever may be the exposure, it is not possible to send patients before the end of June; in regions so elevated as between 3280 and 4921 feet, July, August, and the first half of September are the only months in which one can reside, for any length of time. But, as may be readily supposed, a more or less southern exposure will cause exceptions to this general rule.

Having indicated the most favourable and the most necessary conditions for rendering a mountain residence of real benefit, it only remains for us to give some details, as abridged as possible, as to the resources which Switzerland and some of the adjoining parts of Savoy offer in this point of view.

No valley can be compared with that of the Leman for the variety of its sites. We there find, in fact, almost southern climates, where the oleander and pomegranate tree grow in the open air; while other localities present all the characters of northern climates, where the snow lies for six or eight months, and the vegetation is almost polar.

As an example of the localities where the air is mild and the temperature high during winter, we may mention Montreux and the surrounding villages from Villeneuve to Vevey; and, on the other hand, as sites truly alpestrine, we may name the Ormonds, St Cerques, Lallias, Glion, and many others, whose height varies from 3280 to 3937 feet. We shall commence by enumerating them in their geographical order, and afterwards classify them according to their meteorological properties.

If we take Geneva as a centre whence to set out in search of a place of abode for invalids, we shall find, as has been mentioned, many villages which, by their exposure and difference of level, present some of the characters of a mountain climate, when compared with the town. Such is the case with Lancy (1312), on the eastern declivity of a small hill exposed to all winds, and particularly to the north wind, which renders the air of this locality remarkably bracing; Jussy (1551), which is in a similar situation, and offers the same characters; Cologny (1495), and Bessinges (1636), where Colonel Tronchin has erected an establishment for convalescents which appears to exercise a very favourable influence on all who require to be strengthened; Burdigny (1531), Peissy (1640), and Choully (1656), which are brought very near Geneva by the railway, and offer most valuable resources to patients.

To the villages just named, may be added others whose situation singularly adapts them to such as require an air at once mild and stimulating, such as Champel (1364), Grand-Sacconex (1476), Petit-Sacconex (1453), Pregny (1485), Chambesy (1285), Chouny (1535), and Vaudoeuvres (1525). If we compare these different sites with the town of Geneva (1230), we shall not, perhaps, find the difference of level so considerable as to justify us in expecting much change, and yet medical experience testifies to the contrary; for I can refer to patients who experience very marked effects by a change of height not exceeding 65 or 98 feet; as, for example, from the lower part of the town to the highest streets, or to the plateau of Tranchées or Champel.

If we proceed from the immediate vicinity of Geneva to localities a little more remote, the first we meet with, as enjoying a well-deserved reputation, is Mornex (1630 to 1856), situate on the eastern and southern declivity of the Petit-Salève. This village, which is of great length, offers different sites, more or less sheltered from the north-wind, and has most of the properties we desiderate,—easy access, means of conveyance, comfortable lodgings, and a hydro-therapeutic establishment. Mornex thus enjoys a reputation to which it is well entitled.

Not far from Mornex is a village which forms a complete contrast to it. Situate in the gorge which separates the two Salèves, Monnetier (2335), possesses all the properties of a true mountain climate; the air is keen, constantly renewed, and the temperature lower than at Mornex, so that this locality may be regarded as essentially tonic, and consequently very suitable for patients and convalescents weakened by long confinement, or frequent relapses. Persons affected with anæmia, chlorosis, or hysteria, as well as those suffering from disorders of the nervous system, or liable to passive hæmorrhages, generally find themselves greatly benefited by a residence in this place during the summer months. It will be obvious that one ought to come to it later, and leave it earlier, than Mornex. We must not forget to mention two advantages possessed by Monnetier, and which render it more and more adapted to patients, namely, an excellent carriage-road, which enables the most delicate persons to reach it without quitting their coach, and the rebuilding of the old chateau, which has just been converted into a comfortable dwelling-house, where patients will find all that they can desire, in one of the most picturesque situations that can be found, a steep rock, from which there is a very extensive view of the plain, the lake, and the mountains of our valley.

If, from Monnetier, we ascend the heights of the Grand Salève we find, at 3842 feet, various chalets and dwellings, of a more or less comfortable description, which afford great conveniences to those who seek a truly alpestrine atmosphere. The Treize-Arbres, Grange-Gaby, and some others, situate either on the culminating point of the Salève, or on its eastern declivity, enjoy all the meteorological qualities favourable to health; and it is much to be desired that the intended buildings and carriage-road were speedily completed, that patients may be able to avail themselves of such a valuable place of resort in a neighbourhood so near Geneva.

If we leave the shores of the lake and ascend the course of the Arve to its source in the valley of Chamounix, we shall find various localities more or less suitable. On the sides of the Môle we come to the very picturesque chalets of La Tour (2956), where those who are satisfied with what is strictly necessary, without seeking for luxury or indulgence, will find a very agreeable abode among meadows and fir-woods, which rise to the summit of the Môle (6128). The same thing may be said of the chalets situate on the plateau of the Voirons, below the summits of the Calvaire (4777), and the Pralaire (4613), where the invigorating air will make ample amends for any defect of comfort.

The valleys of Samöens (2329), and of Sixt (2444), may likewise be chosen for the same purpose. Their easy access, and the boarding-houses and hotels lately established in these places, hold out inducements to patients to make them their residence.

Such, likewise, is the case with the village of St Gervais (2674), which is situate above the baths, on a very steep hill, and presenting the most varied prospects. The invigorating air of this place, the excellent hotel of Mont-Joly, and the delightful excursions which may be made to the places around, have long caused the village of St Gervais to be a residence highly appreciated by the sick and convalescents. All who have there recovered their strength and health retain the most agreeable recollection of it, and are ready to recommend their friends to follow their example.

Not far from St Gervais, lie the valley of Chamounix and the village of Prieuré (3451), which is well known as an object of picturesque excursions, and which in every respect deserves its European reputation, but which may also be sought for on account of its height and truly alpestrine climate. The great advantages in lodgings, diet, and means of conveyance possessed by the village of Chamounix, may in my opinion be turned to the best account by all whose health requires an atmosphere essentially tonic. The result has confirmed my anticipations; and it is from actual experience that I can recommend a sojourn of some weeks in this elevated valley. The most suitable season is that of the great heats, which are very endurable at Chamounix, owing to the currents of cold air which descend from the high peaks and refresh the atmosphere.

If we come back to Geneva, and turn towards the side of the Jura, we shall find, between the lake and the mountains, numerous villages, many of which are very well situated, and present favourable conditions; such as Divonne, which unites two advantages, an invigorating air and a well conducted hydro-therapic establishment; Crassier (1562), Gilly (1584), where there is a house for convalescents established by M. Eynard, and which daily renders great services; Gingins (1788) which has good boarding-houses; Aubonne and Lavigny (1712); Orbe (1466), and a few others.

As we approach the Jura, many localities occur, which present in various degrees the characters of mountain climates.

Such is the case with Vallorbe (2569), and the valley of the lake of Joux (3362), and particularly St Cergues (3432), a village placed at the entry of the passage of the Rousses on the eastern declivity of the Jura, in a very favourable exposure. The air breathed in this place possesses all desirable qualities, so that St Cergues during the summer season is either the abode of invalids, or a starting-point for excursions to the neighbouring summits, especially to the Dôle (5449), at the foot of which it is situated.

In the environs of Morges, Lausanne and Vevey, are to be found many stations which may be chosen for the purpose of which we are now speaking; such are the numerous plains situate on the high ground which overlooks Lausanne, between the Croisettes (2624), and the Chalet-à-Gobet (2838). Further to the east, the tower of Gurze (3044), and on the hills which rise above Vevey, between the lake and the Dent de Jaman, the sulphurous baths of Lallias (3448), where there is a well-managed establishment, wholly surrounded with woods and green sward; Charney (5334), which by its southern exposure unites the characters of a mountain climate with those of a mild and almost southern atmosphere; the Pleiades, situated at the foot of the mountain of that name (4488), to the north-west of Vevey; Avants (3212), where there is a good inn; and, lastly, Glion, one of the best localities, situated on an isolated round hill, immediately above Montreux, which it overlooks like an eagle's nest. On this picturesque site an excellent hotel has recently been built, at the foot of the Dent de Jaman, and in front of it one of the most beautiful views found in our valley, a position which has deservedly procured for it the name of the *Vaudese Righi.*

When we ascend the course of the Rhone, and leave the valley from Aigle on the way to the mountain, we find at the foot of the Diablerets a very picturesque valley, that of the Ormonds, which is divided into two parts. The Sépey, or Ormond-dessous, is 3704 feet in height; while the Plans, or Ormond-dessus, is 3815 feet. At some distance, in the valley of the Mousses, we find a good hotel, much frequented, especially by the English, at Comballaz (4426). These different localities, and particularly the latter, are situated, as has been seen, at a great height above the level of the sea; they accordingly enjoy an essentially alpestrine climate; the air is invigorating, the temperature moderate, even when the heat of the plains is intense. It is not surprising, therefore, that the Ormonds should be much frequented in the summer season. Sépey is reached by a good road, and the lodgings and diet are such as to leave nothing to be desired. Many invalids of my acquaintance have there obtained fresh vigour, bodily and intellectual; others, more easily impressed, have experienced vertigo and palpitations, occasioned by the keenness and rarity of the air; while the majority of them have derived substantial benefit from an abode in this delightful valley. But it must not be forgotten, that its considerable height does not admit of a visit before the month of July, nor a stay beyond the end or even middle of September, especially in the most elevated station, that of Comballaz.

Leaving the latter place, and crossing the Col du Pillon, we reach the valley of the Simmenthal and that of the Vaudese Gruyère, whose numerous villages have become, like the Ormonds, objects of excursions and places of abode. Chateaux d'Oex (3260) and Rossinière contain many boarding-houses, where everything may be found that can be desired.

The neighbourhood of Bex (1424) may likewise be selected for the purpose in view; the Plans (3674), Grion (4051), and Chesières (4002), do not supply all the conditions of easy access and comfort which may be desired, but the vivacity and purity of the air, as well as the vicinity of such a town as Bex, partly make up for these inconveniences.

On the other side of the Rhone, ascending the Val-d'Ilier as far as Champéris (3385), we come to the village of that name, in the bottom of a beautiful valley, situated on the eastern slope of the Tours-Sallières, at the point where the passage of the Cols de Coux and de Champ unite, and in a highly picturesque situation. The lodgings and victuals have been improved of late years, so that we may venture to recommend Champéris as a medical station, as well as a starting-point for excursions into the neighbouring valleys of Mont Blanc.

The Valais is rich in alpestrine localities, among which are to be specified Zermatt (5331) at the foot of Monte Rosa, and

Loëche (4458), both of which are very well known to tourists and invalids. They are placed at a great height, almost in the immediate vicinity of the glaciers, and consequently possess an essentially tonic atmosphere. Although Loëche is frequented chiefly for its thermal waters, there can be no doubt that its elevated position greatly contributes to the benefit of the numerous invalids who take up their abode there every year.

Immediately above Neufchâtel is the mountain of Chaumont (3845), where patients may reside with advantage. If we leave the capital of the canton and repair to the north-west, we arrive at the Vallées, which are so well known as the seat of manufactures, but which may likewise be resorted to as a mountain country by engravers and clockmakers who wish to re-establish their health without interrupting their work. They may choose, according to the nature of their occupation, either Locle (3021), Chaux-de-Fonds (3392), or Chaux-du-Milieu (3533).

In the immediate vicinity of Soleure rises the Weissenstein, where we find, at the height of 4206 feet, an excellent inn, well known to the inhabitants of the neighbourhood, who resort to it to be cured by drinking whey.

The Bernese Oberland, which is justly so much resorted to as one of the most beautiful countries of the world, may likewise become a place of rendezvous for all who wish to sojourn for a time among the mountains. They will find there very diversified stations, from the margin of the lakes of Thun and Brienz to the baths of Rosenlaüi. Let us notice some of these localities in succession, and endeavour to indicate the characters peculiar to each of them.

We may name, in the first place, the baths of Gurnigel (3789), where one breathes a perfumed air, in the midst of magnificent fir-woods, and having a most extensive view in front; all make use of the sulphurous waters. The baths of Blumenstein (2205) are much less elevated than these, but may in some respects serve similar purposes. The same may be said of Thun (1844), Interlacken (1837), Brienz (1916), Meyringen (1988), and still more decidedly of Lauterbrunnen (2595), Grindelwald (3432), or the baths of Rosenlaüi (4432), which, owing to their great elevation, cannot be visited except in the warmest months of the year. The immediate vicinity of the glaciers, and the numerous excursions which may be made in the neighbourhood, make Rosenlaüi a very agreeable station when the weather is fine, and the snows of the Scheideck have disappeared from the paths.

If we leave the canton of Berne and visit the lake of the Four Cantons, we find, in the first place, the Righi (5938), the most elevated abode in Europe, to which numerous invalids resort every year in search of some alleviation of their maladies, as well as the re-establishment of their strength, exhausted with fatigue or suffering. The establishment of Kaltbad admits of the combined use of cold water and the restorative air of the high Alps. Persons suffering from chlorosis or hysteria, and particularly hypochondriacs, obtain great relief by this combination of two means of cure contributing to the same object.

In front of the Righi, and on a promontory elevated 968 feet above the lake of Lucerne, stands Seelisberg (2405), a village admirably situated in a country which abounds in picturesque sites. It is accordingly a place of resort during a few of the warm weeks of summer, and a good number of convalescents and invalids can speak of the benefits they have derived from it.

Ascending the course of the Aa, we arrive at Engelberg (3389), in the centre of a delightful valley, rich in points of view and alpestrine walks, which have long made it in request by tourists and valetudinarians.

Returning to the most picturesque lake of Switzerland, and perhaps of the whole world, that of Lucerne, we find many villages on its banks which may be chosen for a temporary abode. The greater number of them have inns or comfortable places of residence; others are less fortunate, but of these the number is decreasing every day. A very comfortable inn has just been built on the Stossberg, at the height of 6978 feet, in a locality which commands an enchanting view.

In the adjoining districts, the canton of Appenzell has also its contingent of villages recommended by medical men. This is the case with Gais (3031), where visitors come to inhale the mountain air, and benefit by drinking goat's whey. Heinrichsbad (2516) and Weïssbad (2690) are also much frequented.

In the neighbourhood of the lake of Zurich, there is an establishment on Mount Albis, where a trial can be made of the cold water treatment, as on the Righi. Dr Brunner's success is no doubt owing to his long experience in hydro-therapics, but the air respired at Albisbrunnen must also be a valuable auxiliary in the cure.

Lastly (for I must hasten to conclude this dry enumeration, which, notwithstanding its length, is no doubt very incomplete), I ought to say a few words on the most highly situated baths of Europe, those of St Moritz, in the canton of the Grisons, 5859 feet above the level of the sea. These ferruginous waters are very rich in mineral matters, and their efficacy is no doubt greatly increased by the position of the place where they are used.

And now that we have taken a review, following the geographical order, of the various villages or establishments which may be recommended to our invalids, it only remains for us to classify them according to their meteorological qualities, which depend especially on the absolute height, and also, though in a smaller degree, on the exposure and configuration of the ground. Keeping in view the whole of these circumstances, we may establish three classes, in which the different localities we have spoken of may be arranged.

I. *Climates at once tonic and soothing* (*below* 3280 *feet*).

Such is the case with Mornex, the villages of St Gervais, Sixt, Samoëns, Chernex, Seelisberg, and a few other stations in the neighbourhood of the lakes of Thun, Brienz, or Lucerne. The greater part of them are situated at a height which does not exceed 3280 feet, and their exposure is almost always eastern or southern.

The patients who ought to avail themselves of this climate, are the dyspeptic, the phthisical in the first stage, the neuralgic, the rheumatic, as well as those recovering from typhoid fever or hooping-cough.

The height and exposure render these different stations habit-able in the spring, and residence at them may be prolonged till autumn.

II. *Tonic and invigorating climates* (*about* 3280 *feet*).

We place in this category the village of Monnetier, the Chalets of Treize-Arbres on the Salève, those of Voirons, Chamounix, the baths of Lalliaz, Glion, Plans near Bex, Château-d'Œx, and Rossinière, the Ormonds, upper and lower, Champeris, and Louesche-les-Bains, Grindelwald, Engelberg, and Gais.

These different establishments are placed at an elevation of about 3280 feet, and if situated lower, they owe their meteorological qualities to a northern exposure, and local circumstances which admit of the atmosphere being frequently renewed.

The patients who can be sent to them with advantage are those affected with chloro-anæmia, hypochondriacs, some neuralgic patients, and such as are subject to passive hæmorrhages, and lastly, puny and scrofulous children.

The heights of these places being considerable, they should not be visited till about the end of spring, and they ought to be left after the autumnal rains have lowered the temperature.

III. *Climates essentially tonic and exciting* (*above* 3280 *feet*).

Such are Comballaz, Grion near Bex, the baths of Gurnigel and Rosenlaüi, the Weissenstein, Stossberg, and the Righi, and lastly, St Moritz in the Grisons.

The air breathed on these heights, which range between 3936 and 5904 feet, will be found too exciting for a great number of patients; but by using the precautions already referred to, some of them derive great benefit. Such is the case with a certain number of hysterical and hypochondriac subjects, as well as persons whose nervous system has been exhausted by too intense study or severe suffering. But it must be recollected that a sojourn of this kind cannot be extended beyond a few weeks, both on account of the exciting qualities of the rarefied atmosphere, and the coldness of the temperature after the summer months have elapsed.

CONCLUSIONS.

Having gone over the whole series of questions which mountain climates, considered in a medical point of view, present to our notice, it only remains for us, before concluding, to sum up in a few words the practical consequences which flow from them.

We have seen that the atmosphere of heights exercises a vivifying influence on the whole economy, which facilitates sanguification, renders digestion more complete, re-establishes the strength, and restores tranquillity to the cerebro-spinal nervous system.

In the second place, we have determined that this kind of climate predisposes to inflammations, hæmorrhages, and asthma.

On reviewing the series of localities most favourable to invalids, we have been able to classify them according to their meteorological qualities; observing in some an air at once tonic and sedative; in others, a climate tonic and invigorating; in others, finally, an atmosphere essentially tonic and very exciting, which consequently is adapted to a very small number of invalids, and during a period comparatively of short duration.

Having then applied the results of experience to each of the localities enumerated, we have determined the curative indications applicable to each of them; so that we have had it in our power, notwithstanding the difficulty of the subject, and the small number of documents relative to it which science possesses, to give some directions for making the most judicious choice both with respect to the different localities, and the different morbid affections which it is expedient to send thither.

May these researches, imperfect as they are, contribute to the cure or alleviation of any who are suffering, and we shall add with the poet,—

"Hoc erat in votis."

N.B.—We must refer the reader to a correction of some inaccuracies in Dr Lombard's paper, as given in a letter from Dr A. Smith, who was long a distinguished medical practitioner in Peru, and who was one of the first writers on the influence of elevation on diseases in the Andes of Peru. This letter appears in the "Extracts from Correspondence" in the present number of this Journal.—[*Edit. Phil. Jour.*]

The Chemistry of the Iron Manufacture of Cleveland District—(continued). By WILLIAM CROWDER, F.C.S., Newcastle-on-Tyne.

FIRST SERIES.

Experiment No. 1, *at No.* 1 *Furnace, May* 20, 1856.

Table showing the load of Hutton stone, hæmatite, and limestone, actually at work at the time the specimens were taken.

N.B. In all these experiments the quantity of coke (30 cwt.) is used as a standard. Any variations in the burden being made in the stone and flux, but the quantity of coke is always the same.

	Cwt.	qrs.	lb.
STANDARD.			
Coke, . . .	30	0	0
CHARGE.			
Hutton stone calcined, .	37	0	0
Hæmatite, . .	2	2	0
Limestone, . .	12	2	0

These weights, calculated on the ton of iron produced, gave—

	Cwt.	qrs.	lbs.
Coke, . . .	38	1	2
Hutton stone calcined, .	47	0	23
Hæmatite, . .	3	0	21
Limestone, . .	15	3	2

Quality of the iron produced, No. 1.

Characters of the iron.—Colour dark grey, fracture open, exhibiting confused facets of graphite over the entire section of the pig; soft under the chisel. The pig exhibited a convexity at the edges; suitable for mixing with scrap or broken castings for foundry purposes.

Analysis of the Iron made at No. 1 *Furnace, May* 20, 1856.

Quality, No. 1.

Residue insoluble in dilute hydrochloric acid = 6·48 per cent.

Analysis of the Insoluble Matter.		*The same after calculating off the Oxygen.*	
Silica,	3·56	Silicon,	1·71
Alumina and trace of iron,	0·60	Aluminium,	0·31
Lime,	0·09	Calcium,	0·06
Magnesia,	0·11	Magnesium,	0·07
		Graphite,	1·86
		Combined carbon,	0·37
Soluble in Hydrochloric Acid.			
Silica,	0·20	Silicon,	0·09
Lime,	0·56	Calcium,	0·40
Magnesia,	trace.	Magnesium,	trace.
Protox. manganese,	0·18	Manganese,	0·14
Phosphoric acid,	1·27	Phosphorus,	0·56
Sulphur,	0·08	Sulphur,	0·08
		Iron,	94·35
			100·00
		Total carbon by chromate of lead,	2·23

The following is the composition of the iron when the soluble and insoluble constituents are added together:—

Silicon,	1·80
Aluminium,	0·31
Calcium,	0·46
Magnesium,	0·07
Manganese,	0·14
Phosphorus,	0·56
Sulphur,	0·08
Graphite,	1·86
Combined carbon,	0·37
Iron,	94·35
	100·00
Total carbon by chromate of lead,	2·23

The characters of the slags were:—

A, 9 A.M.—Compact; glassy on under surface; fracture dull; slightly honeycombed on the upper surface, which was covered with an exceedingly thin but distinct layer of well-defined crystals.

B, 12 N.—Crystalline texture.

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C, 5 P.M.—Roughin. A mass of confused crystals, scattered through which may here and there be detected a few clusters of cubical or short prismatic crystals.

In this set the silica, alumina, and several constituents were repeated.

Analysis of Slags from No. 1 *Iron, May* 20, 1836.

	A, 9 A.M.		B, 12 NOON.		C, 3 P.M.	
					Roughin.	
	I.	II.	I.	II.	I.	II.
Silica,	29·00	29·65	30·70	30·65	...	32·00
Protoxide of iron,	0·58	...	0·64	...	0·65	
Protoxide of manganese,	}	}	}	}	0·13	}
Alumina,	23·73	22·95	20·35	20·75	21·22	22·30
Lime,	36·18	37·96	34·78	37·95*	33·62	33·93
Magnesia,	4·80	4·25	6·75	6·75	3·45	3·00
Potash,	...	...	...	...	0·48	...
Soda,	...	...	...	...	0·29	...
Sulphuret of calcium,	2·02	2·02	2·47	...	2·58	2·58
Phosphuret of calcium (Ca P),	1·57	1·42	1·57	...	2·34	2·31
	97·88	98·15	97·26	...	...	...
Sulphur,	0·90	0·90	1·10	...	1·15	1·15
Phosphoric acid,	2·20	1·98	2·20	...	3·26	3·20
Or Phosphorus,	0·96	0·87	0·96	...	1·43	1·41

FIRST SERIES.

Experiment No. 2, *at No.* 1 *Furnace.*

The second set of specimens from the same furnace was collected two days after, when on No. 3 iron, with a very similar burden of stone :—

	Cwt.	qrs.	lb.
STANDARD,			
Coke,	30	0	0
CHARGE.			
Hutton stone calcined,	37	0	0
Hæmatite,	2	2	0
Limestone,	12	2	0

These weights, calculated on the ton of iron *produced*, give :—

	Cwt.	qrs.	lb.
Coke,	38	0	2
Hutton stone calcined,	46	2	19
Hæmatite,	3	1	2
Limestone,	15	3	10

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* The figures 37·95 for lime indicate the total quantity, as well as that which exists as sulphuret and phosphuret.

Quality of the iron produced = No. 3.

Characters of the Iron.—Upper part of the pig dark grey, from presence of graphite, gradually merging towards the lower part of the pig into a paler aspect, in consequence of absence of graphite; convex at the edges of the pigs; suitable by itself for foundry purposes. Transverse strength of a bar 3 feet between the bearings, 1 inch × 1 inch sectional area, upwards of 730 lbs.

Analysis of the Iron made at No. 1 *Furnace, May* 22, 1856.

Quality, No. 3.

Residue insoluble in dilute hydrochloric acid = 5·28 per cent.

Analysis of the Insoluble Matter.		*The same after calculating off Oxygen.*	
Silica,	3·08	Silicon,	1·48
Alumina and trace of iron	0·52	Aluminium,	0·27
Lime,	0·20	Calcium,	0·14
Magnesia,	0·16	Magnesium,	0·10
		Graphite,	1·10
		Combined carbon,	1·15
Soluble in Hydrochloric Acid.			
Silica,	0·24	Silicon,	0·12
Lime,	0·58	Calcium,	0·41
Magnesia,	0·28	Magnesium,	0·17
Protoxide of manganese,	0·11	Manganese,	0·09
Phosphoric acid,	1·77	Phosphorus,	0·78
Sulphur,	0·09	Sulphur,	0·09
		Iron,	94·10
			100·00
		Total carbon by chromate of lead,	2·25

Subjoined is the composition of the iron when the soluble and insoluble constituents are added together:—

Silicon,	1·60
Aluminium,	0·27
Calcium,	0·55
Magnesium,	0·27
Manganese,	0·09
Phosphorus,	0·78
Sulphur,	0·09
Graphite,	1·10
Combined carbon,	1·15
Iron,	94·10
	100·00
Total carbon by chromate of lead,	2·25

The following were the characters of the slags:—

A, 9 A.M.—Grey compact slag, with few traces of crystallisation, except on the upper surface, where it is slightly developed.

B, 12 N.—The same as (A), but rather lighter in colour.

C, 5 P.M.—(Roughin) crystalline texture.

Analysis of Slags from No. 3 *Iron, May* 22, 1856.

	A, 9 A.M.	B, 12 NOON.	C, 5 P.M.
Silica, . .	30·00	31·00	31·50
Protoxide of iron, .	0·38	0·57	0·64
Protoxide of manganese,	0·24	...	0·14
Alumina, . .	24·78	25·87	23·61
Lime, . .	38·11	35·62	34·47
Magnesia, .	2·20	2·50	3·95
Potash, . .	...	...	1·31
Soda, . .	...	...	0·54
Sulphuret of calcium,	1·46	2·13	1·68
Phosphuret of calcium (CaP),	0·92	0·42	1·17
	98·09	98·11	99·01
Sulphur, .	0·65	0·95	0·75
Phosphoric acid, .	1·28	0·60	1·65
Or, Phosphorus, .	0·56	0·26	0·72

FIRST SERIES.

Experiment No. 3, *at No.* 2 *Furnace.*

The burden of the furnace was as follows:—

	Cwt.	qrs.	lb.
STANDARD.			
Coke, . .	30	0	0
CHARGE.			
Hutton stone calcined,	47	0	0
Hæmatite, . .	3	2	0
Limestone, . .	14	0	0

These weights, calculated on the ton of iron *produced*, gave—

	Cwt.	qrs.	lb.
Coke, . .	32	1	17
Hutton stone calcined,	50	2	8
Hæmatite, . .	3	0	7
Limestone, . .	15	0	19

Quality of the iron produced = No. 5.

Characters of the Iron.—The bright graphite was observed to be entirely absent, and replaced by dull grey points on a pale ground, very aptly described by the term "mottled iron." Used for the manufacture of wrought iron.

Analysis of the Iron made at No. 2 Furnace, May 27, 1856.
Quality, No. 5.

Residue insoluble in dilute hydrochloric acid = 3·04.

Analysis of the Insoluble Matter.		*The same after calculating off Oxygen.*	
Silica,	1·48	Silicon,	0·71
Alumina and trace of iron,	0·44	Aluminium,	0·23
Lime,	0·20	Calcium,	0·14
Magnesia,	0·07	Magnesium,	0·04
		Graphite,	0·74
		Combined carbon,	1·83
Soluble in Hydrochloric Acid.			
Silica,	0·20	Silicon,	0·10
Lime,	0·34	Calcium,	0·24
Magnesia,	trace.	Magnesium,	trace.
Protoxide of manganese,	0·70	Manganese,	0·60
Phosphoric acid,	3·30	Phosphorus,	1.44
Sulphur,	0·16	Sulphur,	0·16
		Iron,	93·79
			100·00
		Total carbon by chromate of lead,	2·57

The following is the composition of the iron when the soluble and insoluble constituents are added together:—

Silicon,	0·81
Aluminium,	0·23
Calcium,	0·38
Magnesium,	0·04
Manganese,	0·60
Phosphorus,	1·44
Sulphur,	0·16
Graphite,	0·74
Combined carbon,	1·83
Iron,	93·77
	100·00
Total carbon by chromate of lead,	2·57

The following were the characters of the slags which in this case were taken respectively at 9 A.M., 12 N., 3 P.M., and 5 P.M., besides which a sample of the Roughin was also collected:—

A, 9 A.M.—Slightly crystalline, glassy on the under surface.

B, 12 N.—Blue colour, more crystalline than (A).

C, 3 P.M.—Slightly crystalline, glassy under surface, like (A).

D, 5 P.M.—Compact, stony fracture, glassy under surface, slightly crystalline on the upper side.

E, Roughin.—Dark grey, almost back, a mass of confused crystallization.

Analysis of Slags from No. 5 Iron, at No. 2 Furnace, May 27, 1856.

	A, 9 A.M.	B, 12 N.	C, 3 P.M.	D, 5 P.M.	E, Roughin
Silica, . . .	30·90	32·75	31·90	32·00	33·55
Protoxide of iron, . .	0·64	1·15	0·80	0·38	0·45
Protoxide of manganese, .	...	...	...	trace	...
Alumina, . . .	24·26	22·51	24·42	22·35	20·46
Lime, . . .	32·84	34·98	34·47	32·76	32·52
Magnesia, . . .	2·95	2·49	4·30	5·46	6·52
Potash, . . .	...	...	...	0·95	...
Soda, . . .	...	...	...	0·43	...
Sulphuret of calcium, .	2·88	2·47	2·70	3·01	2·88
Phosphuret of calcium (Ca P),	2·32	2·42	0·77	1·37	1·47
	96·79	98·77	99·36	98·71	97·85
Sulphur, . . .	1·28	1·10	1·20	1·34	1·28
Phosphoric acid, . .	3·23	3·36	1·08	1·92	2·04
Or, Phosphorus, . .	1·42	1·48	0·47	0·84	0·90

FIRST SERIES.

Experiment No. 4, at No. 2 Furnace.

This set of specimens, from the same furnace as before, was collected two days after, when the furnace was on strongly mottled iron, with a very similar burden to the preceding.

STANDARD.	Cwt.	qrs.	lb.
Coke, . .	30	0	0
CHARGE.			
Hutton stone calcined,	47	0	0
Hæmatite, . .	3	0	0
Limestone, . .	14	0	0

These weights, calculated on the ton of iron produced, gave—

	Cwts.	qrs.	lbs.
Coke, . .	32	0	16
Hutton stone, .	50	1	12
Hæmatite, . .	3	0	24
Limestone, . .	15	0	0

Quality of iron produced = strongly mottled.

Characters of the Iron.—The characters previously described for mottled iron are more strongly developed, in the greater distinction between the dark points and the white background, showing an approach to their total absence, as in white or silvery iron; used in the manufacture of wrought iron.

Analysis of the Iron made at No. 2 *Furnace, May* 29, 1856.

Quality strongly mottled.

Residue insoluble in dilute hydrochloric acid = 3·72.

Analysis of the Insoluble Residue.		*The same after calculating off Oxygen.*	
Silica, . . .	1·84	Silicon, . . .	0·88
Alumina and trace of iron,	0·44	Aluminium, . .	0·23
Lime, . . .	0·31	Calcium, . . .	0·22
Magnesia, . . .	0·14	Magnesium, . .	0·08
		Graphite, . . .	0·86
		Combined carbon, .	1·83
Soluble in Hydrochloric Acid.			
Silica, . . .	0·12	Silicon, . . .	0·06
Lime, . . .	0·43	Calcium, . . .	0·31
Magnesia, . .	trace.	Magnesium, . .	trace.
Protoxide of manganese,	1·51	Manganese, . .	1·18
Phosphoric acid, .	3·61	Phosphorus, . .	1·58
Sulphur, . . .	0·19	Sulphur, . . .	0·19
		Iron, . . .	92·58
			100·00
		Total carbon by chromate of lead, .	2·79

The following is the composition of the iron when the soluble and insoluble constituents are added together:—

Silicon, ...	0.94
Aluminium, . . .	0·23
Calcium, . . .	0·53
Magnesium, . . .	0·08
Manganese, . . .	1·18
Phosphorus, . . .	1·58
Sulphur, . . .	0·19
Graphite, . . .	0·86
Combined carbon, . .	1·83
Iron, ...	92·58
	100·00
Total carbon by chromate of lead,	2·79

The slags in this case were taken at 9 A.M., 11 A.M., 2 P.M., 3 P.M., and 5 P.M.; and the roughin not being all alike in colour, two specimens were selected for examination.

A, 9 A.M.—Very slightly crystalline; light grey colour; glassy under surface; slightly crystalline on top.

B, 11 A.M.—More crystalline than A; filled with large cavities containing crystals; glassy under surface.

C, 2 P.M.—Very crystalline; exceedingly glassy on the under surface, and also in streaks throughout the mass.

D, 3 P.M.—Same as C.

E, 5 P.M—Same as C and D, but less glassy.

F, Roughin.—Quite white, only slightly crystalline as compared with the preceding.

G, Roughin.—Black slag, almost devoid of crystalline texture. Honeycombed on the upper surface.

Analysis of Slags from Strongly Mottled Iron, at No. 2 *Furnace,*
May 29, 1856.

	A, 9 A.M.	B, 11 A.M.	C, 2 P.M.	D, 3 P.M.	E, 5 P.M.	F, Roughin	G, Roughin.
Silica, ...	33·40	33·45	34·05	33·20	32·75	35·35	36·85
Protoxide of iron, .	0·70	1·07	0·96	1·21	1·00	1·60	1·08
Protoxideof manganese	...	...	...	0·62	...	...	...
Alumina, . . .	24·21	26·80	25·85	20·80	26·48	27·86	24·42
Lime, . . .	33·91	34·01	35·40	32·41	33·11	27·97	31·29
Magnesia, . . .	4·54	1·50	1·85	7·34	3·50	5·33	3·28
Potash, . . .	1·23	...	...	...	...	...	...
Soda, . . .	0·56	...	...	...	...	...	...
Sulphuret of calcium,	3·10	2·88	2·43	2·79	2·63	3·42	2·70
Phosphuret of calcium, (Ca P.) . .	0·17	0·14	0·58	0·21	0·14	0·20	0·40
	101·82	99·85	101·12	98·58	99·61	101·73	100·02
Sulphur, . . .	1·38	1·28	1·08	1·24	1·17	1·52	1·20
Phosphoric acid, .	0·26	0·22	0·83	0·29	0·22	0·28	0·57
Or Phosphorus, .	0·11	0·09	0·36	0·13	0·09	0·12	0·25

Annexed are the preceding results tabulated for comparison.

FIRST SERIES.

	No. I.	No. 3.	No. 5, or Mottled.	Strongly Mottled.
Silicon, . . .	1·80	1·60	0·81	0·94
Aluminium, . .	0·31	0·27	0·23	0·23
Calcium, . . .	0·46	0·55	0·38	0·53
Magnesium, . .	0·07	0·27	0·04	0·08
Manganese, . .	0·14	0·09	0·60	1·18
Phosphorus, . .	0·56	0·78	1·44	1·58
Sulphur, . . .	0·08	0·09	0·16	0·19
Graphite, . . .	1·86	1·10	0·74	0·86
Combined carbon, .	0·37	1·15	1·83	1·83
Iron, ...	94·35	94·10	93·77	92·58
	100·00	100·00	100·00	100·00
Total carbon, .	2·23	2·25	2·57	2·79

SECOND SERIES.

Experiment No. 1, *at No.* 1 *Furnace.*

	Cwt.	qrs.	lb.
STANDARD.			
Coke, . .	30	0	0
CHARGE.			
Hutton stone, .	35	0	0
Hæmatite, . .	2	2	0
Limestone, . .	12	1	0

These weights, calculated on the ton of iron produced, gave—

	Cwt.	qrs.	lbs.
Coke, . .	42	3	8
Hutton stone, .	48	1	6
Hæmatite, . .	3	2	8
Limestone, . .	16	3	2

Quality of iron produced, No. 2.

The characters of this iron may be stated to be intermediate between the already described No. 1 and No. 3 qualities.

Analysis of the Iron made at No. 1 *Furnace, August* 1856.

Quality, No. 2.

Residue insoluble in dilute hydrochloric acid = 3·60.

Analysis of the Insoluble Residue.		*The same after calculating off Oxygen.*	
Silica,	1·00	Silicon,	0·51
Alumina and trace of iron,	2·00	Aluminium,	1·06
Lime,	0·22	Calcium,	0·15
Magnesia,	0·12	Magnesium,	0·07
		Graphite,	2·61
		Combined carbon	none.
Soluble in Hydrochloric Acid.			
Silica,	4·52	Silicon,	2·17
Lime,	0·27	Calcium,	0·19
Magnesia,	0·19	Magnesium,	0·11
Protoxide of manganese,	1.93	Manganese,	1·50
Phosphoric acid,	3·49	Phosphorus,	1·53
Sulphur,	trace.	Sulphur,	trace.
		Iron,	90·10
			100·00
		Total carbon by chromate of lead,	2·61

When the soluble and insoluble constituents are added together the composition of this iron is—

Silicon,	2·68
Aluminium,	1·06
Calcium,	0·34
Magnesium,	0·18
Manganese,	1·50
Phosphorus,	1·53
Sulphur,	trace.
Graphite,	2·61
Combined carbon	none.
Iron,	90·10
	100·00
Total carbon by chromate of lead,	2·61

The following are the characters of the slags which were taken at 9, 12, 3, and 5 o'clock:—

9 A.M.—White, compact, and very slightly crystalline, *without* glassy appearance.

12 N.—Do., honeycombed on the surface.

3 P.M.—Do., do., do.

5 P.M.—Do., without honeycomb.

Analysis of the Slags from No. 2 Iron, at No. 1 Furnace, August 28, 1856.

	A, 9 A.M.	B, 12 N.	C, 3 P.M.	D, 5 P.M.
Silica, . . .	29·80	30·10	30·55	31·40
Protoxide of iron, .	0·38	0·26	0·32	0·38
Protoxide of manganese,	...	...	...	0·35
Alumina, . .	27·86	27·02	27·01	26·09
Lime, . . .	36·90	35·97	35·87	33·40
Magnesia, . .	0·88	3·00	2·37	By loss. 3·17
Potash, . . .	...	1·20	...	...
Soda, . . .	...	0·80	...	...
Sulphuret of calcium,	3·71	3·71	3·48	3·93
Phosphuret of calcium,	0·36	0·21	0·34	1·28
	99·89	102·27	99·94	100·00
Sulphur, . .	1·65	1·65	1·55	1·75
Phosphoric acid, .	0·51	0·29	0·32	0·50
Or Phosphorus, .	0·22	0·13	0·21	0·72

In the above analyses the sulphuric acid was determined for the sake of ascertaining whether the omission of this ingredient was likely to influence the analysis by omitting it in general. The following were the results :—

	9 A.M.	12 N.	3 P.M.	5 P.M.
Sulphuric acid, =	0·35	0·20	0·30	0·15

These quantities being so small, it was considered that the determination might safely be omitted, because, when the proneness of sulphuret of calcium to pass by oxidation into sulphate of lime is taken into account, there is little doubt that the sulphuric acid must have been formed after the slag had run from the furnace.

SECOND SERIES.

Experiment No. 2, at No. 2 Furnace.

STANDARD.	Cwt.	qrs.	lbs.
Coke . .	30	0	0
CHARGE.			
Hutton stone, .	50	0	0
Hæmatite, . .	2	0	0
Limestone, . .	15	2	0

These weights, calculated on the ton of iron produced, gave—

	Cwt.	qrs.	lbs.
Coke,	31	2	12
Hutton stone,	51	2	9
Hæmatite,	2	0	12
Limestone,	16	0	7

The iron produced was strongly mottled, and similar to that of the first series.

In another experiment, which was carried on *day and night*, between the 31st of August and 8th of September, the yield of iron, as sêen in the subjoined return, was almost the same as the above.

Return of the total quantity of material introduced into No. 2 *Furnace.*

	Tons.	cwt.	qrs.
Hutton stone,	637	9	0
Limestone,	197	8	1
Hæmatite,	25	4	0
Coke,	378	0	0
	1238	1	1
PRODUCE,			
Slag,	427	5	0
Iron (quality strongly mottled)	246	0	0

Analysis of the Iron made at No. 2 *Furnace, August* 28, 1856.

Quality strongly mottled.

Residue insoluble in dilute hydrochloric acid, 4·24.

Analysis of the Insoluble Residue.		*The same after calculating off Oxygen.*	
Silica,	0·44	Silicon,	0·22
Alumina and trace of iron,	0·48	Aluminium,	0·25
Lime,	0·20	Calcium,	0·14
Magnesia,	0·07	Magnesium,	0·04
		Graphite,	1·51
Soluble in Hydrochloric Acid.		Combined carbon,	1·41
Silica,	0·52	Silicon,	0·25
Lime,	0·52	Calcium,	0·36
Magnesia,	0·38	Magnesium,	0·23
Protoxide of manganese,	2·22	Manganese,	1.72
Phosphoric acid,	3·94	Phosphorus,	1·74
Sulphur,	0·23	Sulphur,	0·23
		Iron,	91·90
			100·00
		Total carbon, by chromate of lead	2·92

The following is the composition of the iron when the soluble and insoluble matters are added together :—

Silicon, . . .	0·47
Aluminium, . .	0·25
Calcium, . .	0·50
Magnesium, . .	0·27
Manganese, . .	1·72
Phosphorus, . .	1·74
Sulphur, . .	0·23
Graphite, . .	1·51
Combined carbon, .	1·41
Iron, . . .	91·90
	100·00
Total carbon, by chromate of lead,	2·92

The characters of the slags which were taken at 9, 12, 3, and 5 o'clock, were :—

9 A.M.—Light grey, very slightly crystalline, slightly honeycombed.

12 N.—Strongly honeycombed.

3 P.M.—Slightly crystalline, very slightly honeycombed.

5 P.M.—Dark grey colour, very slightly crystalline, honeycombed.

Analysis of Slags from Strongly Mottled Iron, at No. 2 Furnace, August 28, 1856.

	A, 9 A.M.	B, 12 N.	C, 3 P.M.	D, 5 P.M.
Silica, . . .	31·25	31·15	31·50	33·00
Protoxide of iron, .	0·45	0·64	0·64	23·00
Protoxide of manganese,	0·97	0·17	1·11	
Alumina, . .	24·58	24·35	20·89	
Lime, . . .	36·45	36·08	34·93	33·40
Magnesia, . .	3·19	5·22	6·60	7·10
Potash, . . .	0·71	...	...	...
Soda, . . .	0·22	...	...	...
Sulphuret of calcium,	3·02	3·03	3·17	3·06
Phosphuret of calcium,	0·20	0·29	0·28	0·36
	101·04	100·93	99·12	99·92
Sulphur, . . .	1·34	1·35	1·41	1·36
Phosphoric acid, .	0·23	0·40	0·38	0·51
Or Phosphorus, .	0·13	0·18	0·17	0·22

The above 31·25 per cent. silica in (A) 9 A.M., after weighing, was fused with carbonate of soda and potash, in order to ascertain whether the slags are completely decomposed by digestion in acid, and the quantity of silica obtained was 31·15, being a difference of 0·10, which is clearly no more than the loss which may be expected in repeating the analysis.

SECOND SERIES.

Experiment No. 3, *at No.* 3 *Furnace.*

STANDARD.	Cwt.	qrs.	lbs.
Coke, . .	30	0	0
CHARGE.			
Hutton stone, .	35	0	0
Hæmatite, . .	3	0	0
Limestone, . .	12	0	0

These weights, calculated on the ton of iron produced, gave—

	Cwt.	qrs.	lbs.
Coke, . .	41	3	19
Hutton stone, .	47	2	0
Hæmatite, . .	4	0	21
Limestone, . .	16	1	19

Quality of the iron produced = No. 1.

Characters of the Iron.—Similar to the No. 1 in first series. In this, as in the preceding experiment, a quantitative determination of the weight of slag and iron was also made, but with this difference, that in the present case the weights were only taken 12 hours a day, between 5 A.M. and 5 P.M., from August 21 to August 30; this includes stoppages.

Return of the quantity of material introduced into No. 3 *Furnace and produce of Slag and Iron.*

N.B. The experiment was only carried on 12 hours per day.

	Tons.	cwt.	qrs.
Hutton stone, .	228	8	0
Hæmatite, . .	20	2	0
Limestone, . .	78	17	0
Coke, . .	201	0	0
Total material introduced,	528	7	0
PRODUCE.			
Slag, . .	169	3	0
Metallic iron, .	96	14	0

Analysis of the Iron made at No. 3 *Furnace, August* 28, 1856.

Quality, No. 1.

Residue insoluble in dilute hydrochloric acid = 3·12.

Analysis of the Insoluble Residue.		*The same after calculating off Oxygen.*	
Silica,	0·64	Silicon,	0·29
Alumina and trace of iron,	0·72	Aluminium,	0·38
Lime,	0·17	Calcium,	0·12
Magnesia,	0·12	Magnesium,	0·07
		Graphite,	1·41
		Combined carbon,	1·09
Soluble in Hydrochloric Acid.			
Silica,	0·64	Silicon,	0·31
Lime,	0·34	Calcium,	0·24
Magnesia,	0·19	Magnesium,	0·11
Protoxide of manganese,	1·12	Manganese,	0·87
Phosphoric acid,	3·57	Phosphorus,	1·56
Sulphur,	0·04	Sulphur,	0·04
		Iron,	93·51
			100·00
		Total carbon by chromate of lead,	2·50

The following is the composition of the iron when the soluble and insoluble constituents aro added together:—

Silicon,	0·60
Aluminium,	0·38
Calcium,	0·36
Magnesium,	0·18
Manganese,	0·87
Phosphorus,	1·56
Sulphur,	0·04
Graphite,	1·41
Combined carbon,	1·09
Iron,	93·51
	100·00
Total carbon by chromate of lead,	2·50

The following are the characters of the slags which were taken at 9, 12, 3, and 5 o'clock :—

9 A.M.—White slag, dull fracture, slightly honeycombed.

12 N.—Very white, slight crystalline fracture, slight honeycombed.

3 P.M.—Do. do. do.

5 P.M.—Do. do. do.

Analysis of the Slags from No. 1 *Iron, at No.* 3 *Furnace, August* 28, 1856.

	A, 9 A.M.	B, 12 N.	C, 3 P.M.	D, 5 P.M.
Silica, . .	29·35	32·95	30·95	32·75
Protoxide of iron, .	0·18	0·31	0·18	0·20
Protoxide of manganese,	0·30	0·40	0·25	0·20
Alumina, . .	21·46	21·07	23·90	21·26
Lime, . .	37·21	33·85	35·32	33·92
Magnesia, . .	6·20	6·79	3·21	5·96
Potash, . .	0·75	...	0·58	...
Soda, . .	0·48	...	0·41	...
Sulphuret of calcium,	3·93	3·60	3·84	3·76
Phosphuret of calcium (Ca P), . .	0·68	0·72	0·68	0·92
	100·54	99·69	99·32	98·97
Sulphur, . .	1·75	1·60	1·71	1·67
Phosphoric acid, .	0·95	1·00	0·96	1·28
Or Phosphorus, .	0·42	0·44	0·42	0·56

Annexed are the preceding results tabulated for comparison :—

SECOND SERIES.

	No. 1 Iron.	No. 2 Iron.	Mottled Iron.
Silicon, .	0·60	2·68	0·47
Aluminium, .	0·38	1·06	0·25
Calcium, .	0·36	0·34	0·50
Magnesium, .	0·18	0·18	0·27
Manganese, .	0·87	1·50	1·72
Phosphorus, .	1·56	1·53	1·74
Sulphur, .	0·04	trace	0·23
Graphite .	1·41	2·61	1·51
Combined carbon,	1·09	...	1·41
Iron, .	93·51	90·10	91·90
	100·00	100·00	100·00
Total carbon,	2·50	2·61	2·92

An apparent anomaly is here observed in the production of No. 1 iron at No. 3 furnace, with a less consumption of coke than in the production of No. 2 iron at No. 1 furnace. This is one of those daily fluctuations to which furnaces are liable, from variations in quality of material and other circumstances.

THIRD SERIES.

The following series of slags and iron were from Messrs Bell Brothers, Clarence Iron Works, Middlesboro':—

The burden of the furnace, &c. is not furnished in this instance, the object being rather to compare the results with those obtained at Messrs Cochrane and Company's, and also to assist in establishing a law which appears to occur in all cases in the gradual change of composition in the slags from 9 A.M. to 5 P.M. I shall have occasion to refer to this more particularly presently.

The slags in this instance were all fused, previously to treatment with acid, as some difficulty was experienced in making the silica filter rapidly when the decomposition was effected by hydrochloric acid. Otherwise the fusion with carbonate of soda was quite unnecessary, the effect being produced equally well with acid.

With this exception, their analysis was conducted as in the two preceding series of Messrs Cochrane and Company.

The slags were collected by my friend Mr Pattinson, the chemist to Messrs Bell Brothers, as well as the specimens of the iron which accompanied them.

Instead of collecting them at intervals of two or three hours, the slags were in this case collected every hour from 9 A.M. to 5 P.M., consequently there are in all nine specimens. It was not deemed necessary to make complete analyses of every one of these; I contented myself with an examination of three, and the silica alone was determined in the remainder.

The following were the external characters:—All white; the earlier ones having a dull fracture, increasing slightly in crystalline texture up till five o'clock; four and five o'clock, were slightly honeycombed.

Analysis of Messrs Bell Brothers' Slags from Foundry Iron.

	No. 1. 9 A.M.	No. 2. 1 P.M.	No. 3. 5 P.M.
Silica, . .	27·65	28·20	29·00
Protoxide of iron, .	0·72	0·94	0·85
Protoxide of manganese,	0·35	0·15	trace.
Alumina, . .	24·69	23·45	23·40
Lime, . .	37·39	36·40	36·38
Magnesia, . .	3·55	3·55	2·80
Potash, . .	0·46	...	...
Soda, . .	0·99	...	...
Sulphuret of calcium,	4·39	4·84	4·61
Phosphuret of calcium,	0·43	0·93	1·18
	100·62	98·46	98·22
Sulphur, . .	1·95	2·15	2·05
Phosphoric acid, .	0·60	1·30	1·65
Or Phosphorus, .	0·26	0·57	0·72

The following are the determinations of silica in the intermediate hours; the above are also inserted for the connection:—

	9 A.M.	10 A.M.	11 A.M.	12 M.	1 P.M.	2 P.M.	3 P.M.	4 P.M.	5 P.M.
Silica,	27·65	27·75	28·50	29·00	28·20	27·00	27·50	27·00	29·00

Subjoined are the analyses of the specimens of iron taken on the same day from the same furnace:—

Analysis of Messrs Bell Brothers' Iron.

Quality, No. 1.

Residue insoluble in dilute hydrochloric acid = 4·40.

Analysis of the Insoluble Residue.		*The same after calculating off Oxygen.*	
Silica, . . .	1·88	Silicon, . . .	0·90
Alumina, . . .	0·52	Aluminium, . .	0·28
Lime, ...	0·31	Calcium, . .	0·22
Magnesia, . .	0·16	Magnesium, . .	0·10
		Graphite, . .	1·40
Soluble in Hydrochloric Acid.		Combined carbon, .	0·56
Silica, . . .	0·72	Silicon, . . .	0·34
Lime, . . .	1·30	Calcium, . . .	0·93
Magnesia, . .	0·27	Magnesium, . .	0·16
Protoxide of manganese,	0·59	Manganese, . .	0·46
Phosphoric acid, .	3·68	Phosphorus, . .	1·62
Sulphur, . . .	traces.	Sulphur, . .	trace.
		Iron, . . .	93·03
			100·00
		Total carbon by chromate of lead, .	1·96

The following is the composition of the iron when the soluble and insoluble constituents are added together :—

Silicon,	1·24
Aluminium,	0·28
Calcium,	1·15
Magnesium,	0·26
Manganese,	0·46
Phosphorus,	1·62
Sulphur,	trace.
Graphite,	1·40
Combined carbon,	0·56
Iron,	93·03
	100·00
Total carbon by chromate of lead,	1·96

Analysis of Messrs Bell Brothers' Iron.

Quality, No. 3.

Residue insoluble in hydrochloric acid = 5·20.

Analysis of the Insoluble Residue.	
Silica,	3·44
Alumina,	0·68
Lime,	0·27
Magnesia,	0·13

Soluble in Hydrochloric Acid.	
Silica,	0·32
Lime,	1·04
Magnesia,	0·27
Protoxide of manganese,	1·04
Phosphoric acid,	3·52
Sulphur,	0·04

The same after calculating off Oxygen.	
Silicon,	1·65
Aluminium,	0·36
Calcium,	0·19
Magnesium,	0·08
Graphite,	0·68
Combined carbon,	1·24
Silicon,	0·15
Calcium,	0·74
Magnesium,	0·16
Manganese,	0·81
Phosphorus,	1·55
Sulphur,	0·04
Iron,	92·35
	100·00
Total carbon by chromate of lead,	1·92

The composition of the iron when the soluble and insoluble constituents are added together, was—

Silicon, . . .	1·80
Aluminium, . .	0·36
Calcium, . . .	0·93
Magnesium, . .	0·24
Manganese, . .	0·81
Phosphorus, . .	1·55
Sulphur, . . .	0·04
Graphite, . . .	0·68
Combined carbon, . .	1·24
Iron, . . .	92·35
	100·00
Total carbon by chromate of lead,	1·92

Analysis of Messrs Bell Brothers' Iron.

Quality No. 4.

Residue insoluble in dilute hydrochloric acid = 2·72.

Analysis of the Insoluble Residue.		*The same after calculating off Oxygen.*	
Silica, . . .	0·60	Silicon, . . .	0·29
Alumina, . . .	0·52	Aluminium, . .	0·27
Lime, . . .	0·20	Calcium, . . .	0·14
Magnesia, . .	0·13	Magnesium, . .	0·07
Protoxide of iron, .	0·16	Graphite, . . .	1·06
		Combined carbon, .	1.26
Soluble in Hydrochloric Acid.			
Silica, . . .	3·24	Silicon, . . .	1.55
Lime, . . .	0·40	Calcium, . . .	0·30
Magnesia, . .	0·13	Magnesium, . .	0·08
Protoxide of manganese,	1·38	Manganese, . .	1·06
Phosphoric acid, .	...	Phosphorus . .	1·57
Sulphur	...	Sulphur, . . .	0·03
		Iron, . . .	92·32
			100·00
		Total carbon by chromate of lead, .	2·32

The following is the composition of the iron when the soluble and insoluble constituents are added together :—

Silicon,	1·84
Aluminium,	0·27
Calcium,	0·44
Magnesium,	0·15
Manganese,	1·06
Phosphorus,	1·57
Sulphur,	0·03
Graphite,	1·06
Combined carbon,	1·26
Iron,	92·32
	100·00
Total carbon by chromate of lead,	2·32

Annexed are the preceding results tabulated for comparison.

	No. 1.	No. 3.	No. 4.
Silicon,	1·24	1·80	1·84
Aluminium,	0·28	0·36	0·27
Calcium,	1·15	0·93	0·44
Magnesium,	0·26	0·24	0·15
Manganese,	0·46	0·81	1·06
Phosphorus,	1·62	1·55	1·57
Sulphur,	trace	0·04	0·03
Graphite,	1·40	0·68	1·06
Combined carbon,	0·56	1·24	1·26
Iron,	93·03	92·35	92·32
	100·00	100·00	100·00
Total carbon,	1·96	1·92	2·32

General Conclusions.

The preceding analyses of slags and irons are exceedingly instructive. Without attempting to extort conclusions which are not perfectly obvious, attention may be directed to a number of facts, developed by the preceding investigation, which seem to indicate a progressive change both in the composition of the slags during their collection from morning till night, and in the composition of the pig-irons from No. 1 to No. 5.

In reference to the slags, it will be seen, that in the eight *sets* examined, the silica increases from 9 A.M. to 5 P.M., and the lime and alumina diminish. The magnesia does not appear to follow any rule; at least, it is not so obvious as that of the other constituents.

With regard to the sulphur and phosphorus, the small quantity of these ingredients, more especially of the latter, renders it very difficult to lay down a rule without exceptions.

Out of the eight sets, the general tendency of the sulphur was to increase from 9 A.M. to 5 P.M. in seven cases; whilst in one case it decreased, but only very slightly. The phosphorus also appears to follow the same law.

The texture is, as a general rule, progressively more crystalline from 9 till 5 o'clock. In the two experiments made on the large scale, the proportion of crude iron to slag was *in each case* exactly as 4 to 7.

The Crude Iron.

In the analysis of the crude iron, a great similarity is observable in the proportion of some of the ingredients, as, for example, in the aluminium, calcium, and magnesium.

The *manganese* appears to increase invariably from No. 1 to No. 5 quality.

Phosphorus also increases decidedly in two series; in the third series it is doubtful.

Sulphur increases slightly.

Graphite decreases from No. 1 to No. 5, whilst combined carbon increases; but this merely confirms an already ascertained fact.

The total quantity of carbon always increases from No. 1 to No. 5.

On a New Species of Eurypterus from the Old Red Sandstone, Herefordshire. By the Rev. W. S. Symonds, F.G.S., President of the Malvern Natural History Field Club.*

The best evidences of the succession of the Old Red Sandstone strata in England and Wales are to be seen along the range of the Black Mountains of Herefordshire, the Fans of Brecon and Caermarthen, the Gadir, near Talgarth, and the Scyrrid and Sugar Loaf, near Abergavenny. The succession and transition from the Upper Ludlow (Silurian) rocks into the Old Red rocks above, may be well studied near Ludlow, in Shropshire, Kington, Herefordshire, and Malvern, Worcestershire; while the mass of Old Red rocks intercalated between the Silurians and the Carboniferous limestone shale, is estimated by Sir Roderick Murchison at "a thickness of not less than 8000 to 10,000 feet." (*Siluria*, p. 242.)

Commencing with the transition beds near Ludlow, we have there the fossil fishes *Plectrodus*, sp. *Onchus Murchisoni*, Ag.; *Cephalaspis* (Pteraspis) *ornatus*, Egerton; *Auchenaspis Salteri*, Egerton; *Cephalaspis Murchisoni*, Egerton; together with the crustaceans *Pterygotus anglicus*, Ag.; *Eurypterus pygmæus*, Salter; and the little mollusc, *Lingula cornea*, so characteristic of the Tilestones. In the Kington district, Mr R. W. Banks discovered many of the heads of those singular fish, *Pteraspis* (Kner.), so closely allied to *Cephalaspis*, associated with the remains of the crustaceans, *Pterygotus anglicus*, *Himantopterus*, and *Eurypterus pygmæus*.

Near Kidderminster, we have gray Tilestones passing upwards into true Cornstones, both the tilestones and cornstones being charged with the remains of *Cephalaspis Lyellii*, *Cephalaspis Lloydii*, *Pteraspis ornatus*, *Pterygotus anglicus*, and *Eurypterus*, the seed panicles called *Parkia decipiens*, and many other vegetable remains. These beds are no doubt Upper Tilestones passing into the Lower Cornstones, which are surmounted by the great overlying masses of Old Red Sandstone and Cornstones, which constitute the mass of so many of the rounded and wooded hills of Herefordshire, Shropshire, and Monmouthshire. Take away the elevated Silurian ranges, and the hills of Herefordshire are Cornstone groups, saved by their hard, impure limestones, from denudation; and though now separated by valleys often many miles across, were once as continuous as the rind of an orange. The *Cephalaspis Lyellii* is an abundant organism of these deposits, and occurs high up in quarries above Foxley and Moccas, near Hereford, on the flanks of Kentchurch Park, Monmouth Cap, and Grosmont Hills, and on the flanks of the Scyrrid and the Blorenge. It will be remembered that the *Cephalaspis Lyellii* is found in the Upper Tilestones, associated with the *Eurypterus*. Above the true Cornstones, near the summit of Kentchurch Park, on the top of Rowlestone Hill, near Eyas Harold, and on the flanks of the Black Mountains, near the Hay, we find a gray building stone of considerable thickness overlying the great mass of Cornstones already alluded to; these gray beds pass upward into dark and chocolate-coloured sandstones, which are succeeded by the quartzose conglomerate of the Upper Old Red. These gray building stones have lately furnished the remains of a well-preserved Eurypterus, a crustacean which is associated with Silurian fishes and shells at Kington, and Old Red Sandstone fish and plants near Kidderminster. For a drawing of this fine fossil I am indebted to Mrs Walter Burrow of Malvern; it was discovered by an intelligent labouring man in a quarry near the church at Rowlestone, between Hereford and Abergavenny, where I carefully examined the correlation of the beds, to which I was conducted by the Rev. W. Wenman, who had obtained possession of the Eurypterus. Mr J. W. Salter, of the Museum of Practical Geology, informs me that he has done me the honour to call the species *Eurypterus Symondsii*, and that he will describe it in the Decades of the Society. Mr Salter also tells me that the chief character of the species of Eurypterus "is the very wide front deeply margined, and the occurrence of those lateral rugæ so peculiar to this species."

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* Read at the British Association for the Advancement of Science, held at Dublin, Aug. 28, 1857.

Theory of Linear Vibration. By EDWARD SANG, Esq., F.R.S.E.

I.—*Notice of the Present State of the Theory.*

In the following pages there is given a strict analysis of the vibrations of a linear elastic system, from which all approximative operations are excluded, and which leads from the assumption that *the redressing tendency is proportional to the disturbance* to the enunciation of an absolutely general law.

This law does not harmonize with the usually received ideas concerning the propagation of sound, and seems, indeed, to be altogether irreconcileable to the undulatory theory of light, so that the train of reasoning which has led to it must necessarily challenge a close scrutiny.

The general problem, "To compute the motions of a system of bodies which attract each other according to a given law," has, as yet, been resolved in a very limited number of cases.

When the system contains only two bodies, the solution has been attained to for a considerable variety of supposed laws of attraction, the most important among which is, when the attraction varies inversely as the square of the distance. These solutions are accomplished by observing that each of the two bodies must move as if it were attracted to the centre of gravity, and by thus reducing the problem to the case of a single body attracted to a fixed point.

Beyond this the labours of the most eminent mathematicians have failed to carry us, except in one or two very restricted examples.

When the attractions are supposed to be directly proportional to the distances and also to the masses of the bodies, it is easy to show that the resultant of all the attractions exerted on any one body of the system must be directed towards the centre of gravity of the system, and must be proportional to the distance from that centre: so that, in this particular case, the law of the motion of the system can be completely investigated; and, so far as I know, this is the only variety of the problem of three bodies that has been solved.

Let A, B, C, D, &c., be the masses of a number of bodies which attract each other as the masses and distances jointly; then, ϱ being a coefficient common to all the system,

$$\varrho \,.\, \mathrm{A} \,.\, \mathrm{B} \,.\, \sqrt{\{(x_{\mathrm{A}}-x_{\mathrm{B}})^2+(y_{\mathrm{A}}-y_{\mathrm{B}})^2+(z_{\mathrm{A}}-z_{\mathrm{B}})^2\}} \qquad (1.)$$

is the value of the attraction subsisting between the two bodies A and B.

In order to compute the effect of this attraction upon the motion of the point A, we decompose it into three tendencies parallel to the directions x, y, z. Now, the cosine of the angle which the line AB makes with the direction x is

$$\frac{x_{\mathrm{B}}-x_{\mathrm{A}}}{\sqrt{\{(x_{\mathrm{A}}-x_{\mathrm{B}})^2+(y_{\mathrm{A}}-y_{\mathrm{B}})^2+(z_{\mathrm{A}}-z_{\mathrm{B}})^2\}}} \quad . \quad (2.)$$

wherefore the effect of the attraction (1), estimated in the direction x, is

$$\varrho \,.\, \mathrm{A} \,.\, \mathrm{B}(x_{\mathrm{B}}-x_{\mathrm{A}}) \quad . \quad . \quad (3.)$$

which is independent of the ordinates y and z.

The total tendency of all the attractions of the other bodies of the system to cause A to move in the direction x must therefore be

$$\varrho \,.\, \mathrm{A}\{\mathrm{B}(x_{\mathrm{B}}-x_{\mathrm{A}})+\mathrm{C}(x_{\mathrm{C}}-x_{\mathrm{A}})+\mathrm{D}(x_{\mathrm{D}}-x_{\mathrm{A}})+\&\mathrm{c.}\}\,;$$

wherefore the second derivative of the variable x_{A} is

$${}_{2t}x_{\mathrm{A}}=\varrho\,\{\mathrm{B}(x_{\mathrm{B}}-x_{\mathrm{A}})+\mathrm{C}(x_{\mathrm{C}}-x_{\mathrm{A}})+\mathrm{D}(x_{\mathrm{D}}-x_{\mathrm{A}})+\&\mathrm{c.}\} \qquad (4.)$$

which, on adding zero in the form $\varrho\mathrm{A}(x_{\mathrm{A}}-x_{\mathrm{A}})$, and placing the origin of co-ordinates at the centre of gravity of the system, becomes

$${}_{2t}x_{\mathrm{A}}=-\varrho \,.\, \Sigma\mathrm{M} \,.\, x_{\mathrm{A}} \quad . \quad . \quad (5.)$$

in which $\Sigma\mathrm{M}$ is used to denote the entire mass of the system.

It results from this value of the second derivative of x_{A}, that x_{A} is a circular function of t, viz.,

$$x_{\mathrm{A}}=\mathrm{U}_{\mathrm{A}} \,.\, \sin\,\{t\sqrt{(\varrho\Sigma\mathrm{M})}+u_{\mathrm{A}}\} \quad . \quad (6.)$$

in which U_{A} and u_{A} are two constants to be determined by the condition of the system at a given epoch.

Similarly for the other ordinates of the body A, we have

$$\left.\begin{array}{l} y_{\mathrm{A}}=\mathrm{V}_{\mathrm{A}} \,.\, \sin\,\{t\sqrt{(\varrho\Sigma\mathrm{M})}+v_{\mathrm{A}}\} \\ z_{\mathrm{A}}=\mathrm{W}_{\mathrm{A}} \,.\, \sin\,\{t\sqrt{(\varrho\Sigma\mathrm{M})}+w_{\mathrm{A}}\} \end{array}\right\} \quad . \quad (6.)$$

Whence there results this remarkable law, that if a system of planets were to attract each other with intensities proportional to their distances and masses jointly, each of them would describe an ellipse about the centre of gravity as its centre; that all the periodic times would be identical, and that the positions of the orbits would be unchanging. Hence at every revolution the old phases and conjunctions would recur.

Now this supposition has considerable analogy with the condition of a congeries of elastic particles; while, at the same time, there is an essential distinction between the two. In an elastic system one body acts only on certain of the others—the coefficients of elasticity are not proportional to the masses, neither are the attractions proportional to the distances, but to the derangements of these distances from their mean state. The elastic system, therefore, wants the very conditions which rendered the previous problem resolvable. The supposition that the attractions are proportional to the distances of the attracting bodies enabled us to separate the variations of the three rectangular co-ordinates, and left us at liberty to treat the motions in the direction x as if those in the directions y and z had no existence; and the supposition that each body of the system attracts every other body, brought into play the property of the centre of gravity; therefore, as both of these suppositions are foreign to the character of an elastic system, this method of analysis fails to apply to it.

The theory of vibration which I am about to give, results from the complete resolution of the problem—"To determine the motions of a system of bodies, the attractions of which are proportional to their distances though not to their masses;" a solution which at once leads to that of the kindred problem—"To discover the law of the motions of a series of particles placed in a straight line and acting on each other by redressing tendencies proportional to the derangements of their distances."

Before proceeding to explain the peculiar artifice by which the variables are separated in the general equation of motion, it may be proper to pass under review the Newtonian theory of sound, since it was while seeking to remedy the glaring deficiency of that theory that I discovered the general principle from which the solution flows.

In order to discover the law according to which sound travels, Newton supposed a line of aërial particles, each acting on the two adjoining ones; and having imagined a peculiar species of vibration among these particles, he sought for the conditions under which such a vibration can exist. Having thus obtained a peculiar phase of the general law, he supposed the particles to become infinitely numerous, and arrived at an expression which he believed to indicate the velocity of sound.

The velocity supposed to be obtained in this way differs greatly from that found by actual observation, and various attempts have been made to remove the discrepancy. The most notable of these attempts is that of Laplace, who has taken into consideration the heat developed by the compression of air, and has argued that this development of heat must augment the coefficient of elasticity. Ivory has followed in the same line; and it has been tacitly admitted that this correction has reconciled the theory of Newton with observation.

For my own part, I never was able to see that Newton has demonstrated anything at all concerning the velocity of sound; or rather I have always felt perfectly satisfied that not one of the conditions of the problem enters into Newton's imaginary solution of it. While studying under the able and almost parental guidance of John Leslie I had ventured to urge this objection against Newton's logic. Careful and repeated revisions only served to confirm my belief in the soundness of the objection; yet I hesitated to lay it before the mathematical world. When such giant minds as Newton, Laplace, and Ivory, have concurred in assent, the gauntlet of an unknown and adventurous knight-errant might only have served to excite derision; but this objection has been strengthened by the long-sought-for and long-despaired-of discovery of a strict and unassailable analysis.

The experimental determination of the velocity of sound is accomplished by creating a sudden concussion, and by observing what time elapses ere the sound of it be heard at a given distance; and the problem is to discover, theoretically, what this time should be. The problem, in relation to discrete bodies may be stated thus:—

A linear series of bodies, A, B, C, ... K, L, M, is united by springs or other elastic connections. The whole being in a state of quiescence, an impulse is suddenly communicated to the one end, A: Query—In what time will that impulse be felt at the other end, M?

Let us see how Newton attempts to answer this question.

He imagines to himself a peculiar kind of vibration among these bodies. Each one is oscillating backwards and forwards about its mean position; the extents, and the periodic times of the oscillations, are all alike; but the bodies A, B, C, &c., are successively a little in retard of their antecedents in respect of the epoch of the oscillation. He then proceeds to inquire under what circumstances such an oscillation is possible; and this inquiry he conducts with great skill and clearness.

He takes two alternate bodies, as A and C, and supposes them to be, by any conceivable means, made to oscillate in the way described, and inquires what must be the relation between the elasticity of the connection and the data of the oscillations, in order that the intermediate body B may also oscillate in the same way.

Let U be the half extent of the oscillation of each body; x_A, x_B, x_C, the distances of each from its point of quiescence, e an unknown coefficient, and u the interval of time between the epochs of the successive oscillations. Then we may put

$$\left.\begin{aligned} x_A &= \mathrm{U}\ .\ \sin e\,(t\quad\ ) \\ x_B &= \mathrm{U}\ .\ \sin e\,(t+u) \\ x_C &= \mathrm{U}\ .\ \sin e\,(t+2\,u) \end{aligned}\right\} \quad . \quad . \qquad (7.)$$

The first and the last of these motions, namely, x_A and x_C, are supposed to be derived from some extraneous source; and the question is, to ascertain whether an elastic connection between A and B, and another between B and C, can keep the intermediate body B vibrating in this way. Let ϱ be the coefficient of elasticity for these connections, then we must have

$$_{2t}x_B = \frac{\varrho}{\mathrm{B}}\left\{ x_A - 2x_B + x_C \right\} \quad . \quad . \qquad (8.)$$

from the action of the springs on the one hand, and

$$_{2t}x_B = -e^2\,\mathrm{U}\sin e\,(t+u) \quad . \quad . \qquad (9.)$$

from the supposed law of motion on the other hand; and our business is to see whether these two equations, (8) and (9), be compatible.

From the known properties of equidifferent arcs we find that equation (8) takes the form

$$ {}_{2t}x_{B} = -\frac{U\rho}{B}\left(2\sin\frac{eu}{2}\right)^{2}\sin e\,(t-u), \qquad (10.)$$

and on comparing this with the preceding value of the second derivative of x_B, we have the same variable factor $\sin e(t-u)$ in both; wherefore, we conclude, that such an oscillation is possible, if the elasticity ρ, and the interval of time u, be arranged so as to satisfy the equation—

$$e = 2\sin\frac{eu}{2}\sqrt{\left(\frac{\rho}{B}\right)} \quad . \quad . \quad . \quad (11.)$$

and if the intermediate body B be at first impressed with the proper velocity.

This is what Newton's demonstration shows; but it is all that it does show.

The corollary which Newton drew from this demonstration is remarkable for its beautiful simplicity.

If a fourth body D be placed beyond C, and be made to vibrate according to the law—

$$x_D = U\ .\ \sin e\,(t-3u) \quad . \quad . \quad . \quad (11.)$$

then an elastic connection between C and D may be substituted for that extraneous influence which sustained the oscillation of C; and, extending this reasoning to any number of vibrating bodies, he reached this beautiful law, that,

If a series of bodies, A, B, C . . . . . K, L, M, *of equal weights be connected by springs, having their coefficient of elasticity* ρ, *and if these be once made to oscillate according to the law—*

$$\begin{aligned} x_A &= U\sin e\,(t) \\ x_B &= U\sin e\,(t-u) \\ x_C &= U\sin e\,(t-2u) \\ x_D &= U\sin e\,(t-3u) \\ \&c. &\qquad\qquad \&c., \end{aligned}$$

then it is sufficient that the oscillations of the two extremes A *and* M *be maintained, in order to preserve those of all the others, provided the equation*

$$e = \text{chord}\ eu\sqrt{\left\{\frac{\rho}{B}\right\}}$$

be satisfied.

In this paraphrase of the exceedingly concise and clear language of Newton I have retained all the essential parts of his reasoning, and have omitted only those considerations by means of which he passed from a discrete series to a concrete line.

The inference which Newton draws from this affords a notable example of *non sequitur*. The region of maximum density of such a pulsation must pass along the series with a velocity determined by the distance between the particles and by the time u; therefore, he concludes, sound must travel with this velocity. To take a homely, but not too forcible, illustration, this is to mistake the seeming longitudinal motion of the threads of a revolving screw for a longitudinal motion of the screw itself.

If I can show that some modes of vibration exist in which the regions of maximum density are stationary, shall I be able thence to argue that the velocity of sound is zero? or if I can prove that, in other modes of vibration, the epochs are coincident throughout the whole length, would that demonstrate the instantaneous transmission of sound? It is not enough to show that such and such a mode of vibration is possible; we must show that it results from the conditions of the problem. Now, the essential character of the Newtonian pulsation absolutely excludes the idea of transmission. The motion of the particle B depends not on that of A alone, but also on that of C: both A and C must be made to vibrate accurately in order that the elasticities of the connections may keep B vibrating in accord with them; and it is to be observed that these elasticities are not capable of communicating that oscillation to B, —they are only able to maintain it after it has been begun. So also with the series of bodies A, B, C, ... K, L, M: the oscillations of the first and last must be maintained, and those of all the intermediates must be begun simultaneously and accurately, otherwise their motions cannot be predicted by the formula. So far, then, is Newton's investigation from indicating the time in which sound is transmitted from A to M, that it actually presupposes the whole column A . . M to be sounding, in order to bring the motions within the scope of analysis. Nay, more: if the extreme bodies A and M be so far separated that $e \, . \, mu$ is half a revolution; that is, to say if A be at its extreme right when M is at its extreme left position, the very oscillations of A and M, which are consistent with the progression of epochs t, $t-u$, $t-2u$, &c., would also be consistent with the progression t, $t+u$, $t+2u$, &c. In other words, the same motions of A and M may support, indifferently, an oscillation which gives a progression from A to M, or one which gives a progression from M to A, according as the initial velocities of B, C . . . K, L are arranged. Hence, then, in order to test the result of Newton's reasoning by experiment, we must identify one of his pulses, and follow it along the vibrating column. It will be time enough to reconcile theory with observation when such an observation shall have been made.

As I have already said, the true conditions of the problem are represented by supposing a string of bodies A, B, C, . . K, L, M, connected by elastic ties and in a state of repose, to receive a sudden impulse at one end.

Perfectly satisfied that the only mode of determining theoretically the velocity of sound is to trace the effect of an impulse given to an elastic series in repose, I had often unsuccessfully attempted the solution of the problem as now stated.

When the railway was constructed from Manchester to Liverpool the problem again appeared, but with a new aspect; it became this,

To discover the effects of a collision upon a train of wagons fitted with elastic buffers.

Stimulated now by the practical importance of the subject I again and again renewed my attempts, but without success.

The moment that the body A begins to move, the spring which connects it with B is compressed, and B also begins to move: the spring between B and C is compressed, and induces motion in C, reacting also to retard the advance of B, and so on all along the series; wherefore even the initial motion of B cannot be ascertained without taking all the other bodies into account. The very first step, then, to the solution of the problem must be the complete integration of all the equations of motion.

In the month of November last (1855), while explaining to a young friend the source of the difficulties of the question, I was fortunate, by following out a particular train of thought, to discover a general method by which these integrations can be effected, and which readily extended to the investigation of the motions of a system of bodies which attract each other with intensities proportional to their mutual distances, though not to their masses.

(*To be continued.*)

On the Electric Fishes as the Earliest Electric Machines employed by Mankind. By George Wilson, M.D., F.R.S.E., Regius Professor of Technology, University of Edinburgh.*

Were the question put to a circle of scientific men, "With what form of electrical apparatus were mankind first acquainted?" we should be certain to hear much ingenious discussion concerning the date of Von Kleist's earliest Leyden jar (1745), Hauksbee's glass friction-machine (1709), and Otto Von Guericke's famous sulphur ball (1670). Few, however, would go further back than this primitive instrument, unless the magnet were included among electrical apparatus, which in the form of the compass-needle it cannot be; and even if we dignified with the name of instruments the pieces of amber and precious stones which the predecessors of Guericke rendered attractive and luminous by friction, we should gain nothing by going beyond 1600, when Gilbert, the introducer of the word *electricity*, published his truly scientific treatise "De Magnete." The discussion would thus range at utmost over only two centuries and a half; and as the Magdeburgh sphere of sulphur is the earliest artificial arrangement which can be fairly called a machine, our oldest electrical instrument is apparently less than 200 years old.

Such, accordingly, has been the conclusion of our historians of Electricity; nor did it occur to me, whilst prosecuting researches into the early history of electrical instruments, to doubt its accuracy. Last summer, however, I was directed towards a new channel of inquiry, by a paper read to the Archæological Institute at its meeting in Edinburgh by my colleague Professor Simpson, in which he drew attention to the application of the living torpedo as a remedial agent by the ancient Greek and Roman physicians, in demonstration of the antiquity of the practice of employing electricity therapeutically. I had not looked at the subject in this light before, but inquiry soon satisfied me that a living electric fish was the earliest, and is still the most familiar, electric instrument employed by mankind. Before entering into the proof of this it is worth while noticing, that although the historians of Electricity have not overlooked the fact that the ancients were aware of the electrical powers of the torpedo, they have passed unnoticed the early therapeutic employment of the fish as a truth which, however interesting to the naturalist or the physician, had no significance for them. Priestley for example, in his "History and Present State of Electricity," 1775, refers to the gymnotus as "possessed of a kind of natural electricity, but different from the common electricity, in that persons who touch it in water are shocked and stunned by it, so as to be in danger of drowning" (vol. i. p. 497), and quotes Muschenbroeck's query, "whether the sensation communicated by the torpedo does not depend upon a similar electricity?" (P. 498.) But both references occur under "Miscellaneous Experiments," illustrating the then "present" state of electrical science, and no historical importance is attached to them. This is the more remarkable, that when Priestley wrote, the only electrical power known to characterize the fishes which he names was that of giving the "shock;" and so marvellous did this phenomenon appear to him, that he goes the extreme length of declaring, that "the electric shock itself, if it be considered attentively, will appear almost as surprising as any discovery that Sir Isaac Newton made; and the man who could have made that discovery by any reasoning *a priori* would have been reckoned a most extraordinary genius."*

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* Read to the Natural History Section of the British Association, at Dublin, August 27, 1857.

It seems strange, after these statements, that Priestley should have given no place in his history either to the ancient recognition of the shock-giving power of the torpedo, or to its application as a remedial agent; but the explanation of his silence probably lies in the fact, that he was not fully satisfied that the shock of the torpedo or gymnotus was electrical. "It is to be regretted," he says, "that none of the persons who have made experiments on these fishes should have endeavoured to ascertain whether they were capable of exhibiting the phenomena of attraction and repulsion, or the appearance of electric light, as experiments of this kind are of principal consequence, and must have been easy to make."* Later historians of Electricity, especially those writing after the experiments thus referred to, had (in spite of their difficulty, which Priestley quite undervalued) been successfully made, have not failed to quote the classical references to the torpedo, but have attached no importance to its medical use; and no Natural Philosopher, so far as I am aware, has even hinted the claim of the electric fishes to rank first in order of time among electrical instruments.

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* Preface to first edition of History of Electricity (1767), p. xv.

The subject is one of greater interest to physicists than to naturalists, but I bring it before the Natural History Section of this Association rather than before the sections devoted to Physics and Chemistry, in the hope of inducing naturalists placed in favourable localities to inquire how far uncivilized nations familiar with electric fishes employ their powers remedially.

The subject admits of a twofold division,—into, 1*st*, The antiquity of the practice of using the electrical fishes as remedial agents; 2*d*, The extent or generality of that practice.

So far as I have yet ascertained, the fishes which have been or are thus employed, are limited to different species of the torpedo, the gymnotus, and the silurus or malapterurus; the first a widely distributed marine genus, the second abounding in many of the rivers of South America, and the third in certain of those of Africa. Of none of these fishes but the gymnotus can it with certainty be affirmed, that those who made use of them were aware that they were electrical instruments; and in the case of the gymnotus this remark applies only to its therapeutic use in very recent times. There is reason, indeed, to believe that it had been employed for centuries by the South American savages as a mysterious heroic remedy; but in speaking of the zoo-electric machine as the earliest electric instrument, I must throughout be understood as looking at the living apparatus from a modern electrician's point of view.

The antiquity of the practice first concerns us, and must be rested chiefly on the case of the torpedo, as employed by the civilized dwellers on the shores of the Mediterranean. From their writings we can trace the practice back for nearly two thousand years; certainly to before the Christian era.

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* Op. Cit., vol. i. p. 498.

a narké on board,"[*] How far the ancients realized this fact. of which to some extent they must have been cognisant, and what devices they followed to induce the torpedo to give its shock, does not appear very clearly from the Greek and Roman writings which have come down to us. Galen's ascription of similar properties to the dead as to the living torpedo, is not reconcilable with the belief that he was fully aware of the purely voluntary nature of the electric discharge. The same remark in all likelihood may be applied to the majority of the ancient practitioners who employed the torpedo in medicine. Nevertheless, it will be seen from their prescriptions, copied in the sequel, that they were generally strict in requiring that the fish should be alive, and whatever antiparalytic virtues Galen may have attributed to its cooked body, "he denies that it has any narcotic effect as a medicine, unless when applied alive" (*De Simpl.* vii.)[†] A similar conviction probably led to the cruel practice of boiling the living torpedo in oil, with a view to produce an anodyne liniment. On this point, as on others connected with the subject before us, we may look for more precise information than at present we possess when the great work on the Greek and Latin physicians, in course of publication at Paris, has made further progress.[‡] Meanwhile, the following references to the torpedo, for the majority of which I am indebted to Dr Simpson, will sufficiently illustrate the electro-practice of the ancient physicians. I quote them in chronological order, so far at least as centuries are concerned. Asclepiades, who flourished in the first century B.C., employed the torpedo in inflammation; but only fragments of his works have reached us. The following reference to these and other pre-Christian writings has been kindly furnished to me by my friend Dr Charles Wilson:—

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[*] "Prose Halieutics," p. 456. It is notorious, also, that electric fishes of various genera have been kept for weeks, or even months, along with other fish, without exerting their fatal electric powers upon them. In the case of the torpedo, indeed, and perhaps also of the silurus or malapterurus, these powers are probably serviceable chiefly as means of defence. It is otherwise with the gymnotus, which systematically kills its prey by electric discharges. Its immense batteries, however, are much more powerful than is requisite for the slaughter of the small fish on which it lives, and are largely employed by it as offensive and defensive weapons. It appears, indeed, to be a pugnacious creature.

[†] See Dr Francis Adams' Commentary on Paulus Ægineta, vol. iii. p. 266.

[‡] "Collection des Médecins Grecs et Latins publiée sous les auspices du Ministère de l'Instruction Publique, par le Dr Ch. Daremberg." Scholars in all parts of Europe are contributors to this important work, which, though chiefly concerned with Ancient Medicine, discusses incidentally nearly all the Sciences, Arts, and Usages of the Civilized Greek and Roman world.

"Of the application of the torpedo as a stupefacient, we find, besides, mention in several writers anterior to Scribonius: Nicander alludes to it; and Asclepiades, who practised medicine in Rome a century before Scribonius, employed it in inflammation; and Anterus, a freedman of Tiberius, was successfully treated for gout through the application of a live torpedo, by advice of Charicles."*

Pliny (first century) has many references to the torpedo, The following is one of the more general and speculative:—

"And then, besides, even if we had not this illustration by the agency of the echeneïs, would it not have been quite sufficient only to cite the instance of the torpedo, another inhabitant also of the sea, as a manifestation of the mighty powers of nature? From a considerable distance even, and if only touched with the end of a spear or staff, this fish has the property of benumbing even the most vigorous arm, and of rivetting the feet of the runner, however swift he may be in the race. If, upon considering this fresh illustration, we find ourselves compelled to admit that there is in existence a certain power which, by the very exhalations, and, as it were, emanations therefrom, is enabled to affect the members of the human body, what are we not to hope for from the remedial influences which nature has centred in all animated beings?" †

The succeeding quotations illustrate more precisely the mode of applying the torpedo:—

Scribonius Largus (first century) thus writes:—"Capitis dolorem quemvis veterem et intolerabilem protinus tollit, et in perpetuum remediat torpedo viva nigra, imposita eo loco qui in dolore est, donec desinat dolor, et obstupescat ea pars; quod quum primum senserit, removeatur remedium, ne sensus auferatur ejus partis. Plures autem parandæ sunt ejus generis torpedines, quia nonnunquam vix ad duas tresve respondet curatio, id est torpor: quod signum est remediationis."*

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* "De Renzi, Storia della Medicina in Italia," t. i. p. 275.

† Natural History, Book xxxii., Chap. ii., Bohn's Translation, vol. vi. p. 4.

Galen (second century) refers in similar terms to the treatment of headache: "Sed et torpedinem totam, dico autem animal marinum, capitis dolores sanare capiti admotam sedemque eversam coërcere à quibusdam est proditum. Verum ego quum utrumque essem expertus, neutrum verum comperi. Eam igitur cum cogitassem vivam esse applicandam, cui caput doleret, posse enim fieri ut hoc medicamentum anodynon esset, ac dolore liberaret similiter ut alia quæ sensum obstupefaciunt, ita habere comperi. Putoque eum, qui primus est usus tali quapiam motum ratione experiri aggressum."†

Aëtius, who wrote in the end of the fifth century, does little more than abbreviate the prescription of his predecessors:—"Torpedo viva apposita diuturnum capitis dolore depellit, et prolabentem sedem intrò pellit mortua verò, aut omnino non, aut modice hæc facit."‡

Paulus Ægineta (end of the sixth or the beginning of the seventh century), who, as his learned commentator, Dr Francis Adams, tells us, "continued to be looked up to as one of the highest authorities in medicine and surgery during a long succession of ages," thus condenses the opinions of his predecessors:—"Torpedo; when applied to the head, *while still alive*, in cases of headache, it procures relief to the pain, probably by its peculiar property of producing torpor; and the oil in which the *living* animal has been boiled, when rubbed in, allays the most violent pains of the joints." § The accomplished scholar, whose translation I have quoted, refers, in the relative commentary and elsewhere (*op. cit.*, vol. i. p. 359), to the general employment of the torpedo by the Greek, Roman, and Arabian physicians, adding the significant query

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* De Comp. Medicament. cap. 1, from "Medicæ Artis Principes," vol. iii. p. 196.

† Galen's Works, edited by Kühn, vol. xii. p. 365. Reference is also made by Galen to the power of the torpedo in producing numbness or torpor, in vol. iv. p. 497, vol. vii. p. 109, and in vol. viii. p. 72, and p. 421, in the same edition of Galen.

‡ Tetrabiblon I. Sermo ii. cap. clxxxv., from "Medicæ Artis Principes," vol. ii. p. 96.

§ The Seven Books of Paulus Ægineta, translated, &c., by Francis Adams, published by Sydenham Society, vol. iii. p 266. See also vol. i. p. 359.

—"Is not this an application of the principle of galvanism in medicine?"

Marcellus (whom I quote out of order) prescribes standing on a live black torpedo, on a moist shore which has been washed by the sea, till torpor is felt through the feet up to the knee, as a cure for gout.*

From these accounts, and especially from that of Scribonius Largus, it appears that in the treatment of severe and obstinate headache, *e.g.*, the torpedo was laid on the aching head, or aching part of the head, and left there till it had thoroughly benumbed it. The fish was probably wetted occasionally with sea-water (as Marcellus plainly intends), or immersed in it, otherwise it must soon have ceased to be "*torpedo viva*;" but whether dead or alive, its good effects must have frequently been owing as much to its acting as a cold poultice or wet bandage, as to its efficiency as an electric machine. It was faith, however, in its electrical powers that led to its therapeutic use; and this is all that concerns the present inquiry.

How early the torpedo was employed in medicine cannot be precisely determined. The labours of Daremberg and his colleagues will doubtless throw light on this point; but as Scribonius Largus, Pliny, and other writers of the first century, all describe the medical use of the torpedo, and Asclepiades and Nicander refer to it a century earlier, it at least dates from before the Christian era. It is probable, also, that the ancient physicians borrowed their torpedinal remedy from the Mediterranean fishermen long after they had acquired faith in it; and altogether we may safely say, in round numbers, that the electrical machine, as embodied in the torpedo, is at least 2000 years old. It is probably very much older, for barbaric nations love what the French call "heroic" remedies; and the shock of the provoked torpedo is likely to have been held medicinal by the earliest fishermen of the Mediterranean sea. It would be interesting to ascertain whether the Italian sailors of the present day have any traditional respect for the torpedo as a mediciner. It is sold in the Neapolitan markets as an article of food; but I do not know if Galen's successors agree with him in imputing to it medicinal virtues after it is cooked. Apparently not, but the naturalists and electricians of Italy, a country prodigal of both, will enlighten us on this not unimportant matter.

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* "Aldrovandus de Piscibus, lib. iii. cap. 45. De Torpedine, § Usus in Medicina." To this elaborate work, which contains the whole literature of the ancient remedial use of the torpedo, I would refer those who wish to prosecute further the medical aspect of a question discussed here only in its relation to physics proper.

Another electric fish besides the torpedo was known to the civilized nations of antiquity, and to nations whose civilization is of much earlier date than that of the Greeks and Romans. The Nile breeds one, if not more electrical fishes; and when we remember what an inquisitive, intelligent people the ancient Egyptians were, and that both their medical skill and their practice of animal worship were likely to interest them in the singular endowments of the electric fish, we may well expect to find its powers chronicled, if not employed, by their priests and physicians. As yet, however, nothing has been extracted from either the hieroglyphics or the paintings on the tombs to fulfil this expectation. A very competent authority, indeed, adduces the *absence* of pictorial representations of the Nile fish from the Egyptian monuments as a proof of the special esteem with which it was regarded. "It might reasonably be expected," says Sir J. Gardner Wilkinson, "that the *raad*, or electric fish of the Nile, would be one of the most sacred, and forbidden for food; and it seems not to be represented among those caught in the ancient fishing scenes." He adds regarding it—"It is a small fish, and the one I saw measured little more than a foot long by four inches in depth, but it had the power of giving a very strong shock. It is the *Melapterurus* (*Malapterurus ?*) *electricus*, and may have been the ancient *Latus*."* Thus far Egyptian antiquity is silent as to the very existence of an electric fish; but the name by which the malapterurus is known to the modern Egyptians, has been referred to as proving that their predecessors had more or less precisely ascertained that the same force which is present in the thunder-cloud is present in the shock-giving fish. If this view is well founded, it is difficult to say how remote the period is to which we must carry back the commencement of electrical science, if not also of electrical art. Mr Murray embodies the questionable view of this subject in the statement, " the silurus of which we have to speak is the *silurus* of the Nile (*Malapterurus electricus*), called raasch [query raad ?], or thunder-fish, by the Arabs."*

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* Popular Account of Ancient Egyptians, vol. ii. p. 192.

Wilkinson, referring to the same subject, says, " The name *raad* (' thunder') is very remarkable, since the modern Egyptians are quite ignorant of its peculiar powers; and if it was borrowed by them from their predecessors, the question naturally arises, Were they acquainted with electricity ? "† The author probably intends here by " predecessors," the more ancient Egyptians, on whose customs and character he has thrown so much light. As the word *raad*, however, is Arabic, its origin, though ancient, may be much later than the latest of the Pharaohs. Assuming, as should seem, this view, Alexander Von Humboldt asks, " Did an ingenious and lively people, the Arabians, guess from remote antiquity that the same force which inflames the vault of heaven in storms is the living and invisible weapon of inhabitants of the waters ? It is said that the electric fish of the Nile bears a name in Egypt that signifies thunder." ‡ It might be pleaded in behalf of this view that the sagacious Arabian physician Averrhoes explicitly affirmed of the torpedo, as Dr Badham notices, that " the power which this fish possesses of affecting the skin, seems to be of a kind analogous to that by which the magnet acts upon steel,"§ and would have extended this explanation to the silurus. To what extent, however, this ambiguous utterance is to be understood as implying the discovery by Averrhoes of the bond which modern science has shown to unite electricity and magnetism, and the expression by himself or his countrymen of this truth in the name given to the silurus, it is needless to inquire, till we have disposed of the philological question, Does the word *raad* really signify thunder-fish ? The reply must be in the negative. Humboldt himself became satisfied of this, and states in a note to the passage already quoted, " It appears, however, that a distinction is to be made between *rahd*, thunder, and *rahadh*, the electrical fish; and that this latter word means simply ' that which causes trembling.' " *

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* Edin. Phil. Jour., July 1855, p. 47.

† Popular Account of Ancient Egyptians, vol. ii. p. 192.

‡ Personal Narrative; Bohn's Edition, vol. ii. p. 131.

§ Prose Halieutics, p. 457.

The question is one which only Arabic scholars can answer, and I have accordingly referred it to Mr Edward Stanley Poole, a learned Orientalist, whose decisive reply I give in full:—" I fear the electric fish of the Nile will not sustain the credit of my ancient Egyptian friends for scientific knowledge. The Arabic appellation of the fish in question, namely *raa'ád*, is certainly given to it on account of its *causing trembling*. This is sufficiently plain, from a comparison of words from the same root; and is expressly asserted in an excellent Arabic work ' Abdollatiphi Historiæ Ægypti Compendium,' p. 82. The Arabic appellation of thunder is somewhat different (*raad*), and has evidently originated from the supposition that thunder is a trembling, or a state of agitation of the clouds; or from its being a cause of trembling. For the former of these two derivations we have the authority of El-Beydáwee (' Commentary on the Kur-án,' ch. ii. v. 18). ' Raa'ád' is a generic noun, and ' Raa'ádeh' is a noun of unity, meaning a single fish of the kind called ' Raa'ád.'

" My reading of these words admits of no doubt, and is well known to Arabic scholars."

The modern Arabic name of the Nile electric fish thus does not justify the conclusion, that the Egyptians of past or present times believed that the shock of the fish was the same in nature as a lightning-shock. A name exactly equivalent in meaning is given, as Humboldt incidentally informs us, to the gymnotus as well as the torpedo, by the South American Spaniards " who confound all electric fishes under the name of *tembladores*, literally " tremblers," or " producers of trembling."†

At the present day the silurus of the Nile is sold in the markets of Cairo, and used as food.

The second point to be considered is the extent or generality of the practice of using electrical fishes as shock-machines. In this, however, as in other matters, it will be found that extension in space to a great degree corresponds to duration in time.

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* Personal Narrative, vol. ii. p. 131.

† Ibid., vol. ii. p. 113.

In ancient epochs the torpedo was probably employed medically on all the shores of the Roman empire, including our own, which it visited, and traces of its therapeutic use probably survive in some of them to the present day. I am unable, however, to indicate any such traces more precise than the recognition of the shock-giving powers implied in its vernacular titles, such as the Maltese "name of *Haddayla*, a term which has reference to its benumbing powers;"* the French one, *La Tremble;* and the English, specially expressive names, *cramp*-fish and *numb*-fish.

One modern people, however, makes use of the torpedo exactly as the ancients did, though whether as a tradition from the Mediterranean electro-physicians, or as an independent discovery, I have not the means of ascertaining. The Abyssinians, Dr Badham tells us, employ the torpedo (I presume from the Red Sea) in the treatment of fever. "The patient is first strapped to a table, and the numb-fish then applied successively over every organ of the body: the operation is reported to be both very painful and very successful."†

It is likely, from what I have to mention of other nations and other electric fishes, that the torpedo is still employed on many shores.

Next to the torpedo, the gymnotus is the most famous among electrical fishes, and it is by far the most powerful. The shock, indeed, of a large gymnotus is so severe, that no lover of heroic remedies, having one at command, need long for a magneto-electric coil machine. Several species or varieties of the fish occur, as Humboldt tells us, in the large rivers of South America, the Orinoco, the Amazon, and the Meta, besides frequenting their tributaries, and the smaller streams of an extensive bordering region. They have accordingly been familiar for centuries to the Indians, who are constantly reminded of their presence, even in rivers too deep to let them be caught or frequently seen, by the shocks which they feel when bathing or swimming in the river.* The shallower streams, also, and basins of stagnant water, near the sources of the Orinoco and elsewhere are, in this writer's words, "filled with electrical eels," so that their shock-giving powers are forced upon the attention of all visiting those districts; and we cannot but feel curious to know whether any therapeutic use has ever been made of living machines so powerful. At first sight it might appear that their very power had prevented their use. Humboldt mentions that "the dread of the shocks caused by the gymnoti is so great, and so exaggerated among the common people, that during three days we could not obtain one, though they are easily caught, and we had promised the Indians two piastres for every strong, vigorous fish."† And that this fear, however exaggerated, is in the main well founded, is rendered certain by the unexceptionable testimony of Humboldt himself, not only in his famous account of the battle between the wild horses of the savannahs and the gymnoti, whose favourite pools they reluctantly invaded, but also in his description of the effect of a gymnotus-shock received in full force by himself.

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* Noad's Electricity, 3d edit., vol. i. p. 241.

† Prose Halieutics, p. 459. Badham does not give his authority.

"It would be temerity," says he, "to expose ourselves to the first shocks of a very large and strongly-irritated gymnotus. If by chance a stroke be received before the fish is wounded or wearied by long pursuit, the pain and numbness are so violent that it is impossible to describe the nature of the feeling they excite. I do not remember having ever received from the discharge of a large Leyden jar a more dreadful shock than that which I experienced by imprudently placing both my feet on a gymnotus just taken out of the water. I was affected during the rest of the day with a violent pain in the knees and in almost every joint. To be aware of the difference that exists between the sensation produced by the voltaic battery and an electric fish, the latter should be touched when they are in a state of extreme weakness. The gymnoti and the torpedos then cause a twitching of the muscles, which is propagated from the part that rests on the electric organs, as far as the elbow. We seem to feel at every stroke an internal vibration, which lasts two or three seconds, and is followed by a painful numbness. Accordingly, the Tamanac Indians call the gymnotus, in their expressive language, *arimna*, which means 'something that deprives of motion.'"* We cannot wonder, then, that the Indians who had had experiences, such as Humboldt underwent, and who, unlike the philosopher, were unacquainted with the limits within which the shock-giving power of the gymnotus is restricted, should be unwilling to provoke its anger. This, however, has not kept them from employing it in medicine. All my information on this point is derived from Humboldt, and he does not enter into details, but the following statement is sufficiently explicit:—

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* Personal Narrative; Bohn's edition, vol. ii. p. 113.

† Op. et loc. cit.

"In Dutch Guiana, at Demerara for instance, electric eels were formerly employed to cure paralytic affections. At a time when the physicians of Europe had great confidence in the effects of electricity, a surgeon of Essequibo, named Van der Lott, published in Holland a treatise on the Medical Properties of the Gymnotus. These electric remedies are practised among the savages of America, as they were among the Greeks."†

I have not been able to obtain sight of Van der Lott's work, but Humboldt plainly records the Indian use of the gymnotus in medicine as a device of the Americans, not an imitation of European practice.‡

From a further statement it appears that the Spaniards had not taught this practice to the Indians, or borrowed it from them. "I did not," observes Humboldt, "hear of this mode of treatment in the *Spanish* colonies which I visited; and I can assert that, after having made experiments during four hours successively with gymnoti, M. Bonpland and myself felt till the next day a debility in the muscles, a pain in the joints, and a general uneasiness, the effect of a strong irritation of the nervous system."*

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* Op. cit., vol. ii. p. 119.

† Op. et loc. cit.

‡ We are indebted to the Dutch for our earliest knowledge of the gymnotus. Muschenbroeck (1762) quotes several of his countrymen as having written regarding it, and refers generally to the "Acta Haarlemensia," as containing further information on the subject. He does not, however, make any allusion to its medical use, although dwelling in exaggerated terms on its electrical powers (Introd. ad Philosoph. Natur., § 902–905). It is probable, nevertheless, that in the archives of the societies of Holland, references to the therapeutic employment of the gymnotus by the Indians will be found. Priestley, who quotes Muschenbroeck, but does not appear certain whether the gymnotus is not a sea as well as a river fish, adds a fact on the authority of Fermin (Nat. Hist. of Surinam, p. 59), which is of some interest, as the sequel will show. One of the Surinam electric fishes (probably a species or variety of gymnotus) is called "*Anguille tremblante*, the trembling eel." (History of Electricity, vol. i. p. 498.)

On this point it remains to state, that even in Europe the gymnotus has been used as an electric machine in the end of last century. One sent from Surinam to Stockholm lived more than four months in a state of perfect health. "Persons afflicted with rheumatism came to touch it in hopes of being cured. They took it at once by the neck and tail: the shocks were in this case stronger than when touched with one hand only. It almost entirely lost its electrical power a short time before its death."† In this case, the gymnotus was known to yield electricity by those who employed it; but the practice was probably borrowed from the aborigines of its native country. At all events, it is quite certain that, alike without knowledge of artificial electrical machines, or acquaintance with the therapeutic uses to which the Greeks and Romans put the torpedo, the wild Indian doctors had made trial of the healing electric virtues of the living gymnotus.

Within the last three years a new electric fish has become known to us, belonging to the same genus as the *silurus* or *malapterurus* of the Nile. It is found in the muddy brackish water of the River Old Calabar, near Creek Town, which lies about sixty miles up that river. This stream empties itself into the Bight of Benin, within a short distance from the delta of the Niger, in lat. 5½° north, and long. 8° east. The fish, accordingly, has been named the *Malapterurus Beninensis* by Mr Andrew Murray, who has described and figured it in the *Edinburgh Philosophical Journal* for July 1855, p. 49. ‡

We are indebted to the zealous and intelligent missionaries of the United Presbyterian Church of Scotland, resident at different stations on the River Old Calabar, for our knowledge of the new species of electric fish. Quite recently they have sent home living specimens, some of which are now in Edinburgh; and through the kindness of Professor Goodsir and Mr Murray, I, along with others interested in the electric energies of the animal, have had the opportunity of observing their shock-giving powers. The shock is a sharp one, felt from the fingers to the wrist, the elbow, or the shoulder, according to the activity of the animal, and the position in regard to it of the hands of the experimenter. The fish varies in length from two to twelve inches, is sluggish in its general movements, but retentive of vitality and electrical energy even in unfavourable circumstances.

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* Op. et loc. cit. † Quoted by Humboldt, Personal Narrative, vol. ii. p. 121.

‡ Mr Murray's description of the *Malapterurus Beninensis* is preceded by an interesting *résumé* of the natural history of electric fishes. An important supplement to this paper is given in the *Edinburgh Philosophical Journal* for October 1855, which also contains a very valuable "Review of the present state of Organic Electricity," by Professor Goodsir of Edinburgh. The electrical powers of the living malapterurus are at present under investigation, and the authors named above will in due time make the results known. I confine myself solely to the special point of which this paper treats.

As soon as my attention was turned to the remedial employment of electric fishes, I proceeded to inquire whether the Africans along the Old Calabar river made any therapeutic use of its malapterurus. But before my inquiries were completed, I learned that the natives did make this use of the fish. In truth, the fact had been published by Mr Murray two years ago, but I had overlooked the circumstance. The statement which is quoted below, is the more interesting, that it was not furnished in reply to queries, but was volunteered by Mr W. C. Thomson, who was stationed for several years at the Creek Town Mission station on the River Old Calabar. Mr Murray says:—"Mr Thomson tells me that the electric properties of the fish are made use of by the natives as a cure for their sick children. The fish is put into a dish containing water, and the child made to play with it: or the child is put in a tub or other vessel with water, and one or more of the fish put in beside it. It is interesting to find that a remedy which has only of recent years come into favour among ourselves, should have been already anticipated by the unlettered savage, who probably has had the remedy handed down to him by tradition from remote generations."*

Unaware of this very precise announcement and inference, I applied to the Rev. W. Anderson, who brought from Old Calabar the living fishes at present in Edinburgh, and received the following answer:—

"In reply to your query, I have to state that I am not aware of any statement having been published in reference to the remedial properties of a shock from the fishes, neither have I ever seen them used in any way in sport;* but Mrs Anderson, to whom belongs all the credit of bringing the fishes home, testifies that the native mothers generally keep one of the fishes in a native-made bason, and that on washing their infants in the morning the practice is to dip either the hands or the feet of the infant, so as to cause it to receive a shock. This is done, they say, for the purpose of *strengthening* the child. The strong and the healthy have to undergo the operation as well as the weak and sickly." And that the fish is not an inactive agent in this singular process may be safely inferred from what follows—"So far as Mrs Anderson's observation goes, there is no liking for the affair on the child's part; plenty of struggling and squalling. The natives use the fish as food."

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* *Edin. Phil. Jour.*, October 1855, p. 379.

A third and independent account of the native usages in reference to the malapterurus has been kindly furnished to me by the Rev. Dr Somerville, who obtained it from Mr John R. Wylie, recently a teacher at Creek Town, Old Calabar, but at present in Edinburgh on sick leave. Mr Wylie says: "The Calabar women use this fish in the following manner: They put one or two, according to size, in a tub of water, and then wash their children (infants) in the tub with the fish and all. They must have a strong sense of the benefit derived from this, as in general they dislike doing anything which makes their infants cry; and this process makes them do so most lustily. They also make the children drink a great quantity of the water in which these fish have been. I have been in yards, and seen, on several occasions, the process described."

The ascription of remedial virtues to the water in which the malapterurus has been kept, is a fact of interest when taken in connection with the similar opinion entertained by the Greeks, according to Ælian, in reference to the water in which a torpedo had lain.

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* This letter is dated August 6, 1857. Mr Anderson has very recently returned to this country, and whilst at Old Calabar, to which he almost immediately goes back, was shut out from English scientific periodicals, and too intently occupied with his religious duties to make investigations in natural history. The statement, accordingly, contained in his letter has all the value of an independent testimony.

After learning these facts, I was anxious to ascertain the native name of the malapterurus. Mr Wylie gives it as, "Ryak eke odumade owo," "*Fish which bites man*, or *Electric Fish*." The Rev. Mr Anderson enters into greater detail. "The native name of the electric fish is Edidem or Edidim. Edidem is the word for *King*, or rather *Emperor*. Old Duke Ephraim, and King Eyamba, too, were called Edidem, *i.e.*, absolute monarchs, for they did what they pleased. King Eyo is not Edidem; he is simply Aboug, *a chief, lord, ruler, limited monarch.*

But the word *dum* (pronounced like the Scottish *tume*, empty) means *to bite;* and if the fish be called edidum or edidim (as some suppose the word to be pronounced), then the meaning is *the biter*, or *the biting*.

I cannot *here* express any opinion as to the correctness of either view. The word may mean *emperor*, *the biting*, or it may have another meaning still, "Edi idim," cont. edidum, "*it is in the spring*, or comes to the spring." * The meaning of the name is thus uncertain.

After the triple testimony adduced, it will not be doubted that the employment of the malapterurus as a remedial electric machine is an established practice among the natives of Old Calabar; and few will question the justness of Mr Murray's inference, that the practice is one of great antiquity among them.

It thus appears, that the nations bordering the Mediterranean, the Abyssinians, the Indians of South America, and the dwellers on the western rivers of Africa, have independently used the torpedo, the gymnotus, and the malapterurus as living shock-machines. The practice certainly dates from before the Christian era, so far as the first-named fish is concerned, and in all probability is of much earlier date for all the electric fishes.

Two conclusions, accordingly, seem unavoidable; namely, 1st, That the oldest electrical machine employed by mankind was the living electric fish; 2d, That the electrical machine most familiar to mankind is also the electric fish. The latter conclusion is of much less interest to myself than the former; and daily as galvanic batteries, and other electrical apparatus, are more widely known, it will become less significant. But as the present usages of uncivilized nations represent their past usages back even to a remote antiquity, the light in which a barbaric people still regards creatures so remarkable as the electric fishes is certain in most cases to illustrate the history of electrical science and electrical art. Writing as a physicist, I would remind naturalists, that it was the careful study of the powers of the torpedo that first enabled electricians to understand some of the most important laws of action of their artificial machines and batteries. I have elsewhere pointed out, that in Cavendish's "Account of some Attempts to Imitate the Effects of the Torpedo by Electricity" (*Phil. Trans.* 1776), will be found the first enunciation of "that distinction between *intensity* and *quantity* as affecting electrical phenomena, which has since proved so important a guide to the explication of electrical problems."* Faraday dwells largely on this point;† nor does it admit of the slightest doubt, that inorganic electricity, both as a science and an art, is very largely indebted to organic electricity, alike for the explanation of the laws which it obeys, and for the contrivances by which it works.

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* After the reading of this paper was concluded, Sir John Richardson "read extracts from a letter to Dr Baikie, now engaged in exploring the Niger, in which that gentleman stated that he had met with an electric fish in Fernando Po, and which Sir J. Richardson believed was identical with the malapterurus, which had been described by Dr Wilson, from the coast of Old Calabar. The natives called this fish the "Tremble-fish" (*Athenæum*, 5th September 1857). Sir John Richardson informed me afterwards, that he understood this word, or rather its African equivalent, to be of native origin, and not a translation from any European language. This, however, is not quite certain.

Every addition, accordingly, to our knowledge of the electric fishes has a value even for the pure physicist; and, so far as the present inquiry is concerned, it is important to remember, that we are as yet ignorant how many such fishes there are, and not less ignorant of the light in which many of those known to exist are regarded by the nations familiar with them. Apart from the marine genera not yet fully investigated, there is every reason to believe, from the statements of Humboldt and others, that undescribed species or varieties of the gymnotus occur in the South American rivers. Dr Barth, in his recent volumes,‡ also mentions that he saw at Yo, on the north shore of Lake Tsad, "*a specimen of the electric fish,*

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* "Life of Cavendish," printed for the Cavendish Society, 1851, p. 466, where the whole question is treated at length.

† "Electrical Researches," third and fifteenth series, January 1833 and November 1838.

‡ "Travels and Discoveries in Central Africa," vol. iii. p. 36.

about ten inches long, and very fat, which was able to numb the arm of a man for several minutes."

Wherever they occur, it would be of interest to learn from the natives familiar with them,—1*st*, What therapeutic or other virtues, good or bad, they attribute to them. 2*d*, To what cause or source they impute their electrical powers. 3*d*, By what name they distinguish them. The name alone, fully interpreted, would often supply some answer to the first two queries. The appellations of Electric Fishes, already in use, are very significant, and divide themselves into two groups. Those in the first refer to the benumbing or deadening *sensation*, produced by the zoo-electric shock: those in the second to the involuntary *muscular contractions*, convulsions, or cramps, which follow all but the slightest electric shock. To the first group belong the Greek term Νάρκη, the Latin *Torpedo*, the Maltese *Haddayla*, and the English *Numb-fish*, which are exactly equivalent in meaning, and recognise mainly that painful, but complex nervous sensation, including both deadness and 'livingness,' which those ignorant of electrical shocks are familiar with as the sensation of one's foot or hand asleep. The Indian (*Tamanac*) name for the gymnotus, *arimna*, translated by Humboldt, "that deprives of motion," belongs to the same category, but perhaps signifies simply "deadening."

To the second group belong the Arabic *Raa'ád*, the French *Tremble* and *Anguille tremblante*, the Spanish *Temblador* and *Tembladera;* besides the Dutch *Sidderaal;* German *Zitteraal;* Swedish *Darrål;* and Danish *Krampeaal;* names for the Gymnotus signifying *Shudder-eel* or *Cramp-eel;* the African word translated by Dr Baikie *Tremble-fish*, and the English *Cramp-fish*, all of which, but especially the last, recognise the powers of the creature as a convulser or shock-giver.

Some of those words are doubtless but translations of older words of similar import. Others are as certainly independent applications of essentially the same name by nations, each of whom invented the term. In no language are the titles of the electric fish more expressive than in our own. A combination of the English names for the torpedo, so as to yield the term *Cramp-Numb-Fish*, would most happily designate any one of the electric fishes.

EXTRACTS FROM CORRESPONDENCE.

On the subject of Mountain Climates. By Dr Archibald Smith, *in a Letter to the Editors of the Edinburgh New Philosophical Journal.*

Gentlemen,—Having resided as a medical practitioner for about twenty years in Peru, traversed its mountains and valleys, and attended much to the different Andine climates and diseases, as modified by elevation above the sea, it is not without satisfaction I now see those subjects taken up, and communicated far and near, in the pages of your accredited Journal.

But as I believe accuracy in the observation and statement of facts, to be *a sine qua non* in the progress of all scientific investigation, I beg leave to invite your attention to some inaccuracies which appear to have crept into the valuable article on "Mountain Climates considered in a Medical point of view," published in your recent number for July 1857, by Dr Lombard, from the Bibliothèque Universelle de Genève.

Without strict regard to the order of arrangement pursued by the writer of the article referred to, I shall at once take upon me to offer some restrictions on the statement about dogs and cats (p. 13).

"Cats cannot live at an elevation above 13,000 feet; carried to this height, they invariably sink, after being seized with very singular shocks of tetanus."

"Dogs bear up longer than cats, especially if they have been whelped in the country. Conveyed to these regions, they may continue to live there for one or more years, although seized with convulsive movements very like those in young dogs when attacked with the dog malady."

On the perusal of the supposed facts here asserted, I was so surprised, that to make assurance in my own mind doubly certain, I immediately wrote to a friend just returned from Peru, for more precise information about travellers' tales so novel as this extraordinary story about dogs in particular. The friend to whom I allude is Mr William Donavon, who passed *thirty years* in that country, where he is universally known and respected, and remarkable for his truthfulness and sincerity of character, as well as the extent and accuracy of his information concerning the Puna districts of the Andes, where he long and successfully employed himself at the mines. The following is his reply to my inquiries in a letter dated London, 4th July 1857:—

"As to cats in the Punas, we have them at Casacancha, Palcamayo, Huallay, in Cerro-Pasco, and in the haciendas around the Cerro. But I have always seen them look very stupid and inactive, always stowed away near the estufa or buchara (the fireplaces), as they could not bear the cold. Moreover, you know there are no mice nor rats in the Punas to call their attention. They do not live long there." Now to say that cats "do not live long" in the above-mentioned localities (not one of which is under 13,000 feet, while Cerro-Pasco is considerably above 14,000 feet), is not the same as to affirm that they "cannot live" at these heights. It appears that they do live, though they be not long-lived in those inhospitable climates, foreign alike to their constitutions and natural pursuits:—they inhabit those regions.

As to dogs, again, Mr Donavon writes,—"In the year 1843, I took to the Cerro a young bull-terrier bitch. She used to go out with me every day, and hunt the llamas on the Pampas. I brought her down to Lima with me once or twice. She never had a fit; but her puppies always died; for with the cold she could not rear one. Old Hodge* had a pointer and spaniel there for several years, and my bitch lived to the year 1852, being then about nine years old. In all the mineral 'haciendas' (grinding and amalgamating establishments), you have numbers of dogs from the coast and Quebradas, and they breed there. As to the shepherd's dogs, on the very coldest Punas you will find thousands of them."

Though from memory I cannot speak with precision concerning the cats, as my friend Donavon is able to do, I can certainly confirm, and that very emphatically, what he says above of the dog species. A dog of my own, cross-bred between an English pointer mother and a Newfoundland father, lived many years at the mines of Cerro-Pasco; and hundreds and thousands of other dogs besides, of which some were water dogs, others for the chase, but most of all sheep and watch dogs; nor can I charge my recollection in any way, that dogs from the warmer valleys that have got over the dog-sickness there, are unusually liable to convulsions on their arrival at the mines. I remember one instance of a bull-terrier belonging to a Cornish miner falling down dead, I believe of apoplexy, while jumping up and fondled by his master,—a solitary case, which might happen anywhere.

All over the pastoral slopes of the Cordillera and Puna ranges, up to the line of permanent snow (at 15,000 feet on northern aspects), dogs swarm round every shepherd's hut; and troublesome customers I often found them in approaching their quarters, which they are all open-mouthed to defend against strangers. And woe to the shepherd without his dogs, for then his flocks would be scattered, and his substance eaten up by the fox! Wherever there are sheep there must be a hardy race of dogs to guard them on the lofty Punas, for these faithful animals always keep out of doors by night to watch the sheep gathered near the station, where the shepherd sleeps warmly in his hut.

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* Captain Richard Hodge of Cornwall, who long resided in Cerro-Pasco.

The division into alpestrine regions, or those situated above 6560 feet, and the subalpine below this limit, which is said to "contain the greater part of the villages or establishments to which patients are sent" (p. 9), very well agrees with the old distinction of Sierra and Costa in Peru.

Thus, the coast climates, which consist of many gradations, extend from the shores of the Pacific to the deep gorges, or narrow ravines that lead to the "Sierra," which begins at the elevation of about 7000 feet, the usual limit of the rain-line on the western slope of the Andes. The coast lands, over a zone of 5000 feet, immediately underneath the rain-line, are rainless and arid in perpetuity; and throughout the other subjacent 2000 feet between this and the sea, the collines, or "lomas," as they are called, are periodically refreshed by sea-vapours and drizzle, and then they become covered with a beautifully luxuriant flowery verdure up to their very tops. This coast vegetation is most abundant about Lima in the months of July, August, and September.

But though the "Costa" division of Peru corresponds very nearly in altitude with the subalpine, as above defined, it differs materially in the other characteristic assigned; for it *does not* contain the villages or establishments to which patients are usually sent, either for the purposes of cure or convalescence. Indeed, if we except Chorrillos as a sanitarium for Lima in the winter months, irrespective of sea-bathing, the climate of the coast all under the elevation of the rain-line, where, as I have said, the Sierra begins, is abandoned by those in search of restoration to a firm state of health for the more invigorating Sierra or Alpestrine regions. And when the sick of the mountains descend to the coast for recovery, they come rather in search of a physician than of a mere change of climate; for the climate of the coast is that of ague, dysentery, and phthisis—diseases little known in the more temperate districts and villages of the upland country.

The term "Puna" appears to be used in Dr Lombard's paper very vaguely; and I know of no such place as "the Valley of Puna," so particularly mentioned at p. 10. The word Puna is not applicable on the Andine chains to any one spot in particular, but to all or any of the cold tracts of natural pasture-land above the elevation of 12,000 feet, where corn cannot attain maturity, nor lucern admit of cultivation. Small patches of green barley may be seen in the little inclosures about the houses in Cerro-Pasco; but even at Quinoa, three leagues lower down, barley rarely attains to perfect ear on account of the blighting frosts; but it produces plenty of "alcaser," or barley straw cut green, to feed mules and horses with in the Cerro. And this leads me to say, by the way, that the climate of Quinoa is very much milder than that at the mines, and resorted to with certain relief by those who suffer from the "veta," "seroche," or Puna sickness (all these names are given to the same ailment), in the Cerro. This disease is seldom, however, so durable or severe as to need any active medical treatment. I have only known one instance of its proving fatal, and that was by hæmoptysis on the Puna, at Casacancha or Palcomayo.* The victim was a youth just arrived from Spain, of a full habit of body, and florid complexion. The pulse, though much accelerated in the seroche illness, soon subsides even at the height of 14,000 feet. When residing at the Cerro-Pasco mines, during the whole of the year 1826, I transmitted regular medical reports of the Company to the late Sir Alexander Crichton, as one of the directors of the Peruvian Mining Company in London, and by referring back to my medical journal of that date, I find that when I dismissed my patients to convalesce, from the effects of acute disease, at our sanitarium in a milder region, the pulse is repeatedly stated by me at 80° in the Cerro.

In enumerating the different effects of a residence in alpestrine valleys, we are told (p. 11), "that the appetite is sometimes increased, but for the most part it is destroyed altogether." On this subject I can say of myself, and the fifty or sixty English under my inspection at Cerro-Pasco in 1826, that our appetite was anything but destroyed. After the symptoms of the seroche passed over, which happened in a few days, the appetite became keen and vigorous, even at that great height; but at our sanitarium Huarriaca, at the elevation of about 10,000 feet, our convalescents seemed never to weary of eating "*choclos*," or the tender maize, a very favourite kind of food in those parts. At Tarma and Obrajillo, too, about the same altitude, patients from the coast, weak, languid, and dyspeptic, in the subalpine climates, find the appetite almost at once restored as they ascend to these bracing hill-land climates.

We are further told, that in man the least exertion is attended with great fatigue in the alpestrine climates, and that beasts of burden lose their strength even more speedily than man, &c.

The fact is here too generally expressed, if it be meant to include the New World in this statement; for as regards Peru, it is only true of exotics, whether these be men or animals, *and that only*

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* Had this youth been conveyed in a litter to a temperate climate at only 10,000 feet elevation, the hæmoptysis would have instantly and spontaneously ceased. It is properly a disease of the coast, from relaxation; and of the high regions of the central Cordillera, from congestion: both extremes are evaded at the elevation of from 8000 to 10,000 feet.

in lofty regions. At the height of from 8000 to 10,000 feet the power of muscular exertion is found to be greatly increased by the native of the coast who ascends to these Sierra climates. The native llama carries heavy burdens on the high Sierra table-lands with far more ease to itself than on the coast. And the native mountain Indian, with his naturally wide and well-expanded chest, is capable of his greatest activity of exertion, with the utmost freedom of respiration, on the cold Punas. It was proved to the satisfaction of all concerned at the Cerro mines, that the Indian born and bred in the adjoining districts and villages could work out his daily stem with a weight of hammer in hand which our powerful-looking Cornish men could not manage. Besides, the Indian, after his subterranean task was finished, used to ascend to open day through steep and slippery shafts, with a burden of ore on his back that would have sunk our less acclimated European to the bottom of the pit. This difference of muscular power between the Indian native and exotic European, was neither to be remedied nor accounted for by the habitual use of coca by the native. The source of the difference lies deeper,—in the organic adaptation of each to the peculiar element in which he was born and permitted to grow to manhood. Were the Cerro-Pasco Indian transported to Cornwall, with the help of all the coca in Peru at his command, he would have no chance with the Tribilcocks and Trewithicks of Truro! With respect to loss of strength on the Andine passes of steep ascent, just like continuous steps of stairs, it is wonderful how seldom the muleteer has occasion to stop his train of mules for the sake of a faint or weary one. True, dead carcases and skeletons "may be seen lying in the elevated passes," and so may they on the arid sands of the coast; and so would they in our streets if every carcase were allowed to remain, as in Peru, where the animal fell. There is no remedy; the old, or lean and diseased sore-backed mule must die in harness. But look to the shaggy Sierra-bred little mule, and see how easily it carries the allotted burden of ten arrobas ten pounds, over the snow-covered passes of the steep western Cordillera, and how lightly, in case of need, it can trot under the same weight over the plains of the Puna. Very fat horses, when pressed in ascending the Cordilleras, are sometimes known, not merely to stop to recover breath, but to fall down dead,—from pulmonary apoplexy I think.

We are further informed (pp. 12, 13), that at La Paz in Bolivia (formerly called Upper Peru), at the elevation of 12,234 feet bulls lose their "combative energies."

I have been long aware, that even the English bull-dog, after a year or two years' residence in Lima, and other relaxing climates on the coast of Peru, really lost his combative energies to a remarkable degree, becoming gradually tame and listless; and I have heard it said that bulls brought from a distance to fight in the ring there, also fell off very much in their combative energies when kept for some time in that climate before they were provoked to the combat; but now, for the first time I learn, that at the elevation of La Paz, these animals are subject to the same deterioration of courage. Cerro-Pasco is at least 2000 feet higher than the height ascribed to La Paz; but yet at Cerro our miners used to enjoy themselves at the bull-fights exhibited there during the Indian festivals; and some of the best fighting bulls are reared on the Puna pasture lands of Huamalies, and other upland provinces.

It so happens, that now-a-days there are never good bull-fights in the Sierra; simply because the Indians of the interior never understood the practice of this art like the dark Zambo of the coast, and much less could they imitate the scientific skill of the Spaniard in this national game of gladiatorship. At the Indian feasts we see the bull led on tied to a lasso, and with the points of his horns cut off, or covered with a knob of wood. And though thus disarmed and lassoed, yet the Indian does not venture to goad the animal to the fight until his own courage be artificially raised by rum or the maize beer called chicha. I suspect something of this sort must also have taken place at La Paz, when the curious traveller jotted down that at the elevation of 12,234 feet bulls were bereft of "combative energies." I, at least, would not like to encounter the untamed bull of the lofty Conchucos, or even the "*toro bravo*" of Junin, at the elevation of 13,000 feet.

I shall not detain you by following Dr Lombard through his enumeration and description of diseases as observed by Dr Tschudi in his travels over the elevated inland districts of Peru. But it may be a mere act of justice to the medical reader to say, that this clever writer and naturalist was never, that I heard of, a regular practitioner in Peru, nor admitted as such by the proper medical tribunal in Lima. His medical experience, therefore, must be considered as of a desultory character; and fairly to be received as the accidental incident of travel, in regions generally without the benefit of a resident physician.

His medical observation and practice on the Andine heights seem to have been different from mine. As an instance of this, I may invite attention to the Urticaria, which is described to be a common sequence of the seroche, or Puna sickness. I can only say that no urticaria-like eruption appeared as a sequel to the Puna sickness in the Pasco Peruvian Mining Company, and yet all of them had suffered more or less severely. I never witnessed any connection between this sort of eruption and the Puna sickness; but were the sequence either common or usual, it could not have escaped my observation under the circumstances of my professional duties to a public company.

The *Meningitis* of Dr Tschudi can be no other disease, I think, than the native Tabardillo, a fatal malady, which much resembles typhus fever, and might, with quite as great propriety, have been called Enteritis as Meningitis; for at one time the gastro-enteric, and at another the cephalic symptoms assume early prominence in the Tabardillo. In pleuro-pneumonia,* the "costado" of the Spaniard and native, it appears that Dr Tschudi pronounces bleeding unsafe; whereas with our people in the Peruvian Mining Company I found bleeding indispensable. *Were the Doctor's patients Indians?*

The Verruga is described as a "pustule or boil;" but it is neither the one nor the other, but just, as its name implies, a wart-like disease of the skin, in which the vascular papillæ, only covered by a thin pellicle at top, bleed profusely from time to time. Among the crop of verrugas some excrescences here and there attain to a considerably larger size than the general stock, and are distinguished by the epithet "verrugas madres" or mother-warts, which occasionally bleed much. This disease is chiefly seen on the western slope of the Andes, and within the rain-line, or in the dry and arid subalpine quebradas.

The reader who may desire to learn more of the climates of Peru in a medical point of view than I can here introduce from my own experience, I beg leave to refer to my *Practical Observations on the Diseases of Peru, described as they occur on the Coast and in the Sierra.* These observations I published in the years 1840 and 1842, in a series of papers in the *Edinburgh and Medical Surgical Journal,* and in 1856 I published an article, to which I may also refer, in *The British and Foreign Medico-Chirurgical Review* for October of that year. [But in referring to this article, which is titled *Influence of the Climates of Peru on Pulmonary Consumption,* I must correct the repeated mis-spelling of the name Tarma, which in the paper is incorrectly printed Zarma.]

Here I meant to have ended; but before doing so, let me say that, in the remarks I have offered at the suggestion of Dr Lombard's valuable contribution, I have been encouraged by that gentleman's own frank acknowledgment that he is still in search of more data and original observations to illustrate a subject of which he has only commenced the investigation. If any of my observations can facilitate his progress in the collection of authentic materials or facts, I will be pleased in thinking that I have not altogether neglected the opportunity of throwing my handful of gleanings into the gathering-in of his general harvest.

One more remark, and I shall have concluded. Turning again to Dr Lombard's article referred to in the *Edinburgh New Philosophical Journal*, I read, under the head of "What are the Meteorological Characters of Mountain Climates?" p. 6, the following general proposition, which, if applied to the Andine climates, needs some limitation:—"The atmospheric pressure diminishes with the height, and the rapidity of evaporation increases with the diminution of atmospheric pressure. The higher, therefore, a locality is above the sea the drier will be the air, and the more speedily will it extract moisture from the bodies exposed to it." Now, I would crave leave to indicate that this rule cannot hold true universally, or in an absolute sense; for much of the effect here ascribed to elevation will depend on solar influence. In illustration of what now occurs to me on this subject, let me say, that during the dry season in the Sierra or alpestrine regions of Peru, I observed that in Cerro-Pasco the sun by day was very scorching, while by night the air was of the freezing temperature. About the height of this season, say July and August, the fauces in many cases, more especially in the white or European race, became so desiccated over night, that one so affected would awake in the morning, having the throat and nostrils incrusted with a dried-up mucous secretion. But in the same locality, during the wet season, that is from November to May, when Fahrenheit's thermometer rarely rises above 42°, or falls so low as 36°, nothing of this painful incrustation is observed in the fauces and air passages: Here, then, at the same elevation, the drying process is greatly influenced by sun and season.

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* *Pleurodynia* and *acute rheumatism* were troublesome affections among the Cornish miners; and I have seen natives disabled by chronic rheumatism in the neighbourhood of Pasco.

In the subjacent valley of Huanuco again, at the elevation of from 6000 to 7000 feet, the air is more uniformly *dry* and serene than at Cerro-Pasco at 14,000 feet, throughout the whole year; and for months no dew is observable, nor is there moisture sufficient in the air to support natural pastures on the adjacent mountains generally, though by irrigation the plains and lower hill-slopes are in the enjoyment of a perpetual spring, and never-ending supplies of fruit, flowers, and crops. But what is true of the relative dry state of the atmosphere on the western slope of the Andes is not so at the same corresponding elevations on the eastern slope: the ascent on the western or Pacific Ocean aspect, is estimated at 232 feet to the mile, while on the eastern or Atlantic side the slope is but 152 feet to the mile. We have seen that the whole sub-alpine range of climate on the western side is nearly rainless, and a zone of about 5000 feet of it absolutely rainless. Whereas on the eastern side, the whole corresponding subalpine region, as far as altitude is concerned, is one continuous forest, with an atmosphere far more damp and humid than that of the lofty Cordillera, for at least eight months in the year. Lieutenant Herndon assures us that the indications of the barometer at the eastern foot of the Andes is not to be depended on. He says, that "the trade-winds are dammed up by the Andes; and that the atmosphere in those parts is, from this cause, compressed, and consequently heavier than it is farther from the mountains, though over a less elevated portion of the earth. See pp. 261-2 of a most interesting work, titled "*Exploration of the Valley of the Amazon, made under direction of the Navy Department, United States.* Part I. By Lieutenant Herndon. Washington, 1853." I am, &c.

ARCHIBALD SMITH.

2 Manor Place, Edinburgh,
21st August 1857.

PROCEEDINGS OF SOCIETIES.

British Association for the Advancement of Science. Dublin, August 26—September 2, 1857.[*]

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

A Report on Theoretical Dynamics, prepared by MR A. CALEY, was read.

A Report on Meteoric Phenomena, prepared by the Rev. Professor POWELL, was presented.

Professor LOOMIS *of the United States,* read a paper *on Certain Electric Phenomena.*

Professor LOOMIS, also read a paper *on the Relative Accuracy of the Different Modes of Determining the Geographical Longitude.*

The Rev. CHARLES EVANS read a paper *on the Interpretation of Certain Symbolic Formulæ, and Extensions of Taylor's Theorem.*

Dr SCHLAGINTWEIT read a communication *on Some Physical and Geological Observations,* made by him in India.

Professor HENNESSY next read a paper *on Simultaneous Isothermal Lines.* Having referred to the part already taken by the Association in connection with the distribution of mean temperature over the surface of the earth, he dwelt on the importance of studying simultaneous distributions of the temperature. The movements of the winds, and in general almost all the daily perturbations of the atmosphere, depending much more on simultaneous conditions of the temperature in different places than on the mean amount over long periods, it would be desirable to attempt to trace the former class of lines, when it was attempted to obtain a complete connection between the different classes of the atmospheric phenomena. The nature of isothermal lines was then adverted to, and the differences between them and those of mean temperature, which might be fairly anticipated. The differences between such lines on the land and sea were characterized, and reference was made to the phenomena of land and sea breezes, which would probably be found to have some connection with the distribution of these isothermals. Professor Hennessy, in conclusion, pointed out that these lines might assist either in further confirming or disproving the supposed connection between terrestrial temperature and terrestrial magnetism.

General Sabine observed that he had not heard for many years views developed on the question of temperature more hopeful than those just brought forward by Mr Hennessy, and he hoped that gentleman would continue his researches on the subject.

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[*] This abstract has been prepared from reports which appeared in "Saunders's News-Letter" and "The Freeman's Journal" of Dublin.

Professor CURTIS read a paper *On a System of Geodetics*, and the conjugate system traced on the two sheets of a surface of centres, with special application to the case in which the two sheets are an ellipsoid and a confocial hyperbaloid.

Mr M. DONOVAN read a paper explaining the construction of *A Moveable Horizontal Sun-Dial*, which shows correct solar time within a fraction of a minute, and communicated some observations on a new acoustic phenomenon.

Professor HENNESSY then read a paper *On the Resistance of Fluids to Solidification by Pressure.* With the aid of the principles developed by Professor W. Thomson and Professor Clausius, it was shown that the efficiency of compression to contract a volume of fluid, as long as it continued in that condition, was much less than its efficiency in producing change of state when the fluid should happen to be so circumstanced as to be incapable of losing the heat acquired by the work performed upon it by pressure.

Papers were read by—

Mr JAMES THOMPSON *on the Plasticity of Ice;*

Captain BLAKELY, *a Mathematical Investigation of the Proportion between the Length required for an Electric Telegraph Cable and its Specific Gravity;*

Mr GUSTAF PLARR read a paper *on Certain Transformations of a Series of Exponentials*, and

Mr JAMES NASMYTH *on some Phenomena in connection with Molten Materials.* He stated, on introducing the subject to the notice of the Section, that his object for so doing was to direct the attention of scientific men to a class of facts, which, although in their main features they might be familiar to practical men, yet appeared to have escaped the attention of those more accustomed to scientific research. The great fact to which he desired to call attention is comprised in the following general proposition, namely: That all substances in a molten condition are specifically heavier than the same substances in their unmolten state. Hitherto water was supposed to be a singular and special exception to the ordinary law, namely, that as substances were elevated in temperature they became specifically lighter; that is to say, water at temperature 32°, on being heated does, on its progress towards 40°, instead of becoming lighter, actually increase in density until it arrives at temperature 40°, beyond which, if we continue to elevate the temperature, its density progressively decreases. From the facts which Mr Nasmyth brought forward, it appears that water is not a special and singular exception in this respect, but that, on the contrary, the phenomena in relation to change of density when near the point of solidification is shared with every substance with which we are at all familiar, in a molten condition; so entirely so that Mr Nasmyth felt himself warranted in propounding as a general law the one previously stated by him, namely, that in every instance which he is acquainted with, a molten substance is more dense or specifically heavier than the same substance in its unmolten state. It is for this reason that if we throw a piece of solid lead into a pot of melted lead, the solid metal will float in the fluid metal. Mr Nasmyth stated that he found that this fact of the floating of the unmolten substance in the molten holds with every substance on which he has tested the fact: upon such, for instance, as iron, silver, copper, tin, lead, zinc, antimony, bismuth, glass, pitch, wax, tallow, &c. He further stated that the law holds with equal integrity in respect to alloys or combinations of various meltable substances. Also, that the normal condition, as to density, is resumed in most substances a little on the molten side of solidification, and in a few cases the resumption of the normal condition occurs during the act of solidification. Mr Nasmyth stated that he considered this subject as well worthy of the attention of geologists, who might find in it a key to the explanation of many phenomena of eruption or upheaval of the earth's crust: namely, that on the approach to the point of solidification, molten mineral substances below the crust of the earth must, in accordance with the before-stated law, expand, and tend to elevate or burst up the solid crust, and also express upwards through the cracked surface streams more or less fluid, of those substances which we know to have originally been in that condition. Mr Nasmyth stated that the aspect of the lunar surface, as revealed to us by powerful telescopes, appeared to yield a striking confirmation of the above remark. He concluded by expressing a hope that the facts which he had brought forward might receive that careful attention which their importance appeared to him to entitle them to.

Sir W. R. HAMILTON read an abstruse paper *on some Applications of Quaternions to Iones of the Third Degree.*

Signor BOLZANI read a communication by the Cavaliere O. F. Mossotti, *on the Distribution of the Orbits of Comets in Space,* in which he showed, from examinations of the newest data of the positions of comets, and by drawings and diagrams, that the culminating points of most comets was in the direction of the Galaxy, or Milky Way, and that those proceeding from other regions are in less number the farther they recede from the zone in which that congeries of stars is seen.

Professor HENNESSY read a paper *on the Direction of Gravity at the Earth's Surface.* For all practical purposes, he said, the direction of gravity was considered perpendicular to the earth's surface; and a similar assumption was often made in writings claiming a high degree of scientific accuracy. This arose from defining the earth's surface as the surface of equilibrium of the waters. If the earth were stripped of its fluid covering, the irregular surface so laid bare might be intersected by a surface so placed that the volume of all the eminences rising above it would be equal to the volume of all the depressions. With the data at present possessed it would be nearly possible to have the mean surface. They were not in a position to say how far it approached or differed from a surface of equilibrium, or in other words, they could not assume that gravity was rigorously perpendicular to such a surface. Actual observation showed that in many places it was not so, and this non-perpendicularity was generally referred to irregularities of surface. If, as everything led them to believe, the earth was originally in a state of fusion from heat, all the strata of equal density of the fluid mass would be surfaces of equilibrium. Following out the theory, the paper went on to show that if it could be ascertained what was the form of the outer surface of the earth's solidified crust, and the distribution of the water over it, they might be able to determine whether changes of internal structure took place within the earth subsequent to the formation of that crust. Observations showed that such internal changes had taken place, and consequently that the direction of gravity might have changed.

Professor JELLET read a paper *on some General Propositions Connected with the Theory of Attraction.*

M. LEON FOUCAULT addressed the Section in French upon a *Telescope Speculum of Silvered Glass.* After a brief but lucid description of the telescope, he pointed out the difficulties which were found in its construction in the two different kinds of instrument—those which formed the image by refraction, and those in which the reflection was thrown upon a metal surface. He pointed out the difficulties of working out the achromatic telescope and their causes, and the still greater difficulty which was found in giving the precise form to the metal surface before it was capable of producing accurate images. The great and almost insuperable difficulty of repolishing the metal speculum was explained, as but a very minute fault rendered the instrument valueless. He remarked upon this branch, that as the metal surface was of course easily tarnished, and therefore requiring to be repolished frequently, there was the more danger of destroying the mirror altogether. It occurred to him, he said, that it might be possible to form a reflecting surface, which should be easily figured, easily restored, and which should possess far more illuminating power than either the achromatic or the ordinary reflector, of which the specula are composed of alloy of copper and tin. The process at which he arrived was this:—To form a speculum of glass, no matter how imperfect the material, or how untransparent, provided it was free from air-bubbles. Then he deposited on this a film of silver by a process invented some years ago, and which had latterly been much improved. He found that it could be deposited in uniform thicknesses, exceedingly thin, and that when looked through it was then found to be transparent, and to transmit a blue light, familiar to those experienced in optics. He explained, that when it became necessary, owing to depositions made by the atmosphere, by which the silver became infinitesimally oxidized, it was possible, by light friction of soft leather, charged, if necessary, with peroxide of iron, to remove that obstruction. Thus the speculum was light, unalterable, and extremely strong, and the reflecting surface was extremely brilliant. Inequalities in thickness were at once detected by the transparent quality of the speculum. He also stated the process which he used for depositing the silver, and showed that the coefficient was not less than 0·91. He exhibited one of the specula, and a reflecting telescope, upon the new principle, was placed in one of the windows.

Dr Greer said that he had the pleasure of frequently looking through different mirrors constructed upon the novel principle of M. Leon Foucault. He had put them to a severe test, and he had compared one of seven inches with an excellent achromatic of five inches, and unquestionably that of M. Foucault was the superior.

Professor THOMPSON read a paper by M. Louis Soret *on the Correlation between Dynamical Electricity and other Physical Forces*, and followed it up by some observations, in which he showed that there was nothing novel in the views or experiments recorded in the paper, but that they were valuable as confirming the experiments of Joule.

Mr THOMAS MARTIN *on Certain Properties of the Radii of Curvature of Curves and Surfaces, and their Application to the Method of Polar Reciprocation.*

Major-General SABINE *on the Amount and Frequency of the Magnetic Disturbance and Aurora at Point Barrow, on the shores of the Polar Sea.* The lecturer stated that his results were derived from observations made by Captain Maguire and the officers of the Plover, between July 1852 and July 1854. Point Barrow is situated on the most northern coast of America. Tables made on a large scale were used, exhibiting the variations with and without the disturbances at different hours of the day at Point Barrow and at Toronto. The horizontal force of the earth at Toronto was about double what it was at Point Barrow. It was found that when the disturbances were greatest in amount, the greatest displays, which he considered a magnetic phenomenon, took place. The last letter he had received from Sir John Franklin expressed that navigator's determination to put up instruments for the observation of those phenomena at the several stations at which he might winter. It could not be doubted that such observations were made and recorded with the instruments they took for that purpose. It could not be doubted that when they were detained at some point the following year they carefully made the observations, and it was possible they might have even extended them to another winter. These observations were numerous, and were of such a kind as would have been left in the ships when the explorers proceeded overland. When he (General Sabine) was with Captain Parry in 1818, they made observations as to the figure of the earth, and various other matters, on their way to Behring's Straits. They were exposed to considerable risk of the ships being lost, and when about to take to the boats and proceed overland, they merely carried with them an abstract of the observations, leaving the full records deposited in cases in the cabins of the ships. He had no doubt that in the ships of Sir John Franklin his observations were to be found; and this was the reason why men of science were so anxious to recover the ships; for, first of all, the journals would contain valuable information, and next, it was a sacred duty to those who had lost their lives in gaining such important results to do them the justice and honour of bringing them to light.

Captain Maguire said that the most interesting part of the phenomena they observed was the aurora. At seven o'clock in the morning the magnet used to be most disturbed, and then there was seldom any appearance of aurora. All nature was then perfectly still, and the clouds and snow could not be distinguished from each other. The rays of the aurora used to shoot to a point over their heads, and were so beautiful, that although the temperature was 40° below zero, they used never to be tired looking at them. He had observed at some periods the temperature of the water to be 28° above zero (Fahrenheit), and that of the air to be 40° below zero, so that the water had the appearance of a boiling sea. The observations were made under his directions by Mr Hall and Dr Simpson.

The Rev. Professor HAUGHTON read a paper by Dr SIMPSON, R.N., of the Plover, *On the Temperature of the Air, registered at the Plover's winter quarters at Point Barrow, in the years* 1852-3-4. Having read the paper, Professor Haughton observed that the results communicated on this occasion were an answer to the unfounded popular cry that no good results had accrued to science from the Arctic expedition. Many more observations made in ships engaged in eastern and western expeditions existed, and these also ought to be made available to science. Through the kindness of Captains Maguire and Collins some of them had been placed at his disposal; but he believed there were in the Admiralty many more observations, mathematical, tidal, and meteorological, which ought to be made available.

Rear-Admiral FITZROY drew the attention of the section to *the meteorological papers* lying on the table, which had been recently published by the Board of Trade. The report to which he referred would show what progress had been made, and therefore he would not occupy valuable time by entering into details. He would only observe, generally, that a great number of valuable observations had already been made on board some hundred ships with excellent instruments, approved by the Kew Committee of the British Association, and that those observations were regularly tabulated in such a manner as to admit of their being combined in groups, or used individually. The worthy co-operation of officers at sea had already accumulated more observations than could be reduced and tabulated with duly corresponding quickness. Therefore more reduction of observations, rather than more observers, with a larger number of instruments, seems necessary, and this can only be accomplished by employing a larger staff. Government has shown the utmost willingness to attend to the recommendations of competent authorities with respect to the establishment and support of the meteorological office at the Board of Trade, and only desired to apply the vote sanctioned by Parliament for meteorological observations at sea to the best possible advantage. The United States, Great Britain, and Holland, had already co-operated largely in this work, and France had just lately established a similar department for collecting and discussing such observations.

Professor W. THOMPSON exhibited and explained *Mr Whitehouse's Relay and Induction Coils in action on short circuits.* The peculiarities of Mr Whitehouse's induction coils, which fit them remarkably for the purpose for which they are adapted, as distinguished from the induction coils by which such brilliant effects of high intensity were described. The chief part of the receiving apparatus, the relay, was fully described, and was shown in action after some introductory remarks, explaining the general nature of a relay, an electrical hair trigger. The relation of Mr Whitehouse's relay to the Henley receiving-instruments was pointed out. The author expressed his conviction that, by using Mr Whitehouse's system, to take advantage of each motion for a single signal instead of the to and fro motion, as in all systems hitherto practised, the Henley single needle instrument might be easily used so as to give as great a speed on one line of wire alone as is at present attained by two with the double-needle instrument. The beautiful method of reading by bells would be most ready and convenient for giving the indications to be interpreted as the messages; but the author believes that either by the eye or ear the messages may be read off with the rapidity and care which will render the use of one telegraphic wire in all respects as useful as that of two.

Professor THOMPSON made a communication *on the Effects of Induction in Long Submarine Lines of Telegraph.* A general explanation of the theory was given, and the law of squares was demonstrated to be rigorously true. It was pointed out, that when the resistance of the instruments employed to generate and to receive the electric current are considerable in comparison with the resistance of the line, the phenomena do not fulfil the law of squares, because the conditions on which that law is founded are deviated from. The application of the theory to the alternate positive and negative electrical actions used by Mr Whitehouse for telegraphing was explained, and the circumstances which limited the speed of working were pointed out. Curves illustrating the enfeeblement of the current towards the remote end, and the consequent necessity of the high-pressure system introduced by Mr Whitehouse, were shown. The embarrassment occasioned by the great electrical effect through the wire which follows the commencement of a series of uniform signals with a full strength of electric force, was illustrated in one diagram, which showed a succession of eight impulses, following one another at equal intervals of time, and giving only one turn of the electrical tide at the remote end, or two motions of the relay, including the initial effect. The remedy was illustrated by another diagram, in which a succession of seven equal alternate applications of positive and negative force, following a first impulse of half strength, was shown, proving seven turns of the tide at the remote end, following one another at not very unequal intervals of time, and consequently giving eight turns of the relay, or eight distinct signals.

M. RAILLARD made a communication entitled an *Examination of some Problems in Meteorology; New and Complete Explanation of the Rainbow.*

Professor HENNESSY read two papers, one *on Vertical Movements in the Atmosphere*, and the other *On the Distribution of Heat over the British Isles.*

The Rev. George Salmon, F.T.C.D., *on the Surface of Centres of an Ellipsoid.*

Mr Daniel Vaughan *on Secular Variation in Lunar and Terrestrial Motion from the Influence of Tidal Action.*

Dr Lee *on the Discovery of the Asteroid No. 46, on the 17th August 1857, by N. Pogson, at Oxford.* The official duties of the discoverer at the Observatory at Oxford prevented him from being present at the present meeting. The asteroid was named Hestia, and was discovered by Mr Pogson at his private residence. In 1856 he discovered the planet Isis on the 28th of May in the Radcliffe Observatory; he also discovered Ariadne on the 15th of April; and he was the second discoverer of Amphitrite on the 2d of March 1854.

Dr Lee presented certain results of some measures obtained by Rear-Admiral Smyth *on the Double Star of Virginis* for the epoch 1857. It had been assiduously watched by astronomers, and offered phenomena sufficient to induce the conviction that the Newtonian law of gravitation obtained in the remote stellar regions.

Professor Callan read a paper on *The Electrodynamic Induction Apparatus.*

Sir W. A. Hamilton explained *Tables by Mr C. Thompson to Simplify and Render more General the method of finding the Time of Observing Circumpolar Stars in the same Vertical.*

M. Leon Foucault delivered a discourse *on a Modification of Nichol's Prism, or a New Polarizer without Canada Balsam.*

Professor Stokes made a communication *on the effects of Wind on the Intensity of Sound*, in which he propounded the theory, that if a sound be created near the surface of the earth, during the prevalence of a wind in any direction, the retardation of the current of air at the surface, due to friction, causes the wave of sound to lose its spherical form, and to assume that of an ellipsoid, and that this change in the form of the wave causes its intensity of propagation in the direction of the wind near the surface of the earth to be greater than in the opposite direction.

Mr J. P. Hennessy read a paper *on the Origin and Elimination of Euclid's "Reductio ad Absurdum."* The results to which he called attention were, first, that Euclid's indirect demonstrations may be eliminated; and secondly, the origin of indirect proof. He traced the "Reductio ad Absurdum" to its fundamental principles, and pointed out its logical characteristics.

M. C. Fulbrook read a paper *on the Variation in the Quantity of Rain due to the Moon's Position, in reference to the Plane of the Earth's Orbit.* He produced results showing that, during the period immediately preceding and after the ascent of the moon through the plane of the earth's orbit from S. to N., a greater quantity of rain fell than had fallen during the corresponding period of the moon's descent through the plane of the same orbit. He supposed that what happened in southern latitudes was exactly the reverse.

Mr J. J. Murphy read a paper containing *A Proposal for the Establishment of a Uniform Reckoning of Time over the World, in connection with the Electric Telegraph.* The period in all probability was not remote when the telegraph would effect an almost instantaneous communication between parts of the world which were separated by an extensive arc of longitude, and differed in their solar time by several hours. The system which was introduced all over Great Britain, of keeping Greenwich time, could not be applied over extensive arcs of longitude. A difference of half an hour between solar time and clock time at any place was no inconvenience, but a difference of six hours would be much too great. It would be necessary for distant places to continue to keep their local solar time; but in order to time the receipt and dispatch of telegraph messages, it would be necessary either to reduce the time of one place to that of any other with which it communicated, or to adopt a uniform reckoning of time for all. Mr Murphy proposed a simple self-acting method for meeting the requirements of the case. Let every electric telegraph station that communicates with distant stations be furnished with a clock, similar in other respects to a common clock, provided with a double circle of figures on the dial, the inner circle being fixed as in the common clock, but the outer one being capable of being moved round. Let some one meridian, say that of Greenwich, be chosen as that to which all others shall be referred. Let every such clock throughout the world indicate Greenwich time on the inner or stationary circle of figures; but when a clock is set up at any station, let the outer circle be moved round and set, so that while the hour hand shows Greenwich time on the inner circle, it may show local solar time on the outer circle. The perfect convenience of this plan is obvious. It reconciles the necessity of keeping local time with the advantage of uniform time, and gets rid of any trouble in reducing the one to the other. The system might be rendered more workable still by abolishing the distinction of east and west longitude, reckoning either all east or all west from 0 to 360, and by abolishing the distinctions of A.M. and P.M., reckoning time from midnight up to 24 o'clock.

M. L'Abbe Moigno observed that a practice of this kind was already in use in France.

Dr STEVELLY brought under the notice of the section a paper by Mr James Drummond, entitled *Outline of a Theory of the Structure and Magnetic Phenomena of the Globe.* It started from the generally received hypotheses that the earth had cooled from a molten to a solid state, and assumed the existence, within an external crust constituting the earth's surface, of a fluid nucleus agitated by a system of internal tides similar to those of the ocean, and also of mountainous inequalities upon the inner surface of the crust. The internal agitations of the fluid nucleus accounted for earthquakes, volcanic and magnetic phenomena on the exterior of the earth.

All the papers having been read,

The President said, we now adjourn the section, with the hope that, when it meets next year, we shall be enabled, at the close of its deliberations, to report as satisfactory a performance of its duties as has taken place on this occasion.

SECTION B.—CHEMICAL SCIENCE.

Professor W. K. SULLIVAN read a paper *upon the Occurrence of the following Acids of the Series* $C_n H_n O_4$ *among the Products of the Distillation of Peat, Formic Acid, Acetic Acid, Propionic Acid, and Butyric Acid.* He stated that he first observed the presence of butyric acid in the acetic acid prepared from peat about five or six years ago, but had not an opportunity of examining the subject further until recently, when he became possessed of a large quantity of raw products of peat, which he hoped gradually to investigate. The process of separating the acids, and the result of the analysis of some of the compounds of each, were fully described. The salt of baryta, which was obtained with butyric acid, contains four equivalents of water, and therefore corresponded with one of Chancel's salts. The tendency of butyrite of baryta to crystallize in

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the anhydrous form was remarked to the great difficulty of obtaining the hydrated ones, which accounts for Lerches having always obtained that salt as an anhydrous one.

Professor W. A. Miller remarked on this point, that butyrite of baryta appeared to be capable of forming several salts, and that he had obtained it in plates or tubes not unlike the prussiate of potash. This salt was anhydrous. The salt of potash examined by Professor Sullivan crystallized in pearly scales; it was not therefore the salt of the acid first observed by Mollner in the fermentation of conida, tartrate of lime. Professor Andrews mentioned the interesting facts, that the acids found by Professor Sullivan as a product of distillation had likewise been found by Dr Hodges of Belfast to be formed in process of the preparation of flax.

Professor ANDREWS read a communication *on the Action of Heat upon Ozone*, with some observations on the occurrence of that body in the atmosphere.

Dr VOELCKER read a paper *on the Proportion of Organic Phosphorus in Legumin.*

Dr GLADSTONE read a paper *on the Novel Use of the Prism in Detecting Impurities.* The author described the methods of examining substances by means of a prism, especially the instructive results obtained with liquids when the ray of light traverses them in a wedge-shaped vessel. He suggested this as a means of detecting coloured impurities when they do exist, and of proving their absence when they are wrongfully suspected. He showed the value of the means in respect to coloured confectionery, tea, and mustard, and remarked on its use in examining wines, liquors, pigments used in the fine arts, gems, pharmaceutical preparations, &c. He stated that the prism and hollow wedge were already used as a commercial means of ascertaining the purity of certain substances.

Mr MICHAEL DONOVAN read a paper *on Hygrometers and Hygrometry.*

Dr STEVENSON MACADAM read a paper by Mr John Kyle *on the Chemical Composition of an Ancient Iron Slag from Ayrshire.*

Professor W. A. MILLER made a communication in the nature of a report *on Electro-Chemistry.* He did not propose to enter into the whole subject, but would confine himself to a very few points, as it was impossible to compress the whole communication into a small space within the time.

When Professor Miller had concluded his remarks, a long discussion ensued, in which Professor Andrews, Mr W. Sykes Ward, Dr Gladstone, Dr Odling, and the President, took part, and the latter regretted that Professor Miller's communication on a subject of very considerable theoretical interest had been so short.

Dr DAUBENY gave an account of *a New Method of Refining Sugar*, conducted at Plymouth by Mr Oxland, and known by his name. It consists in the adoption of the superphosphate of alumina in conjunction with animal charcoal, as a substitute for the albumen usually employed for that purpose. In both cases the object is to separate and carry down the various impurities which colour and adulterate the pure saccharine principle present in the syrup expressed from the cane or other vegetable which supplies it. As, however, bullock's blood is the material usually procured for the purpose of supplying the albumen, a portion of uncoagulated animal matter, together with certain salts, is left in the juice in the ordinary process of refining, which impairs its purity and promotes its fermentation—thus occasioning a certain loss of saccharine matter to result. Nothing of the kind happens when the superphosphate is substituted, and so much more perfect a purification of the feculent matters, under such circumstances, takes place, that several varieties of native sugar, which, from being very highly charged with feculent matters, are rejected in the ordinary process of refining, are readily purified by this method. The employment of superphosphate of alumina also gets rid of so much larger a portion of the impurities present in the sugar, that much less animal charcoal is subsequently required for effecting its complete clarification than when bullock's blood has been resorted to. The quantity of superphosphate necessary for effecting the object is, for ordinary sugars, not less than twelve ounces to the ton; whereas, for the same quantity, as much as from one to four gallons of bullock's blood is found to be required. Dr Daubeny suggested that this re-agent might be advantageously resorted to not only in the purification of sugar, but also in other processes of the laboratory, when the removal of foreign matters, intimately mixed with the solution of a definite component, becomes a necessary preliminary in its further examination.

Mr A. H. Hamilton, son of Sir W. R. Hamilton, read a paper *on Electrical Currents in the Earth's Surface.*

A paper *on various Compounds of Cyanogen*, was read by the President.

The following papers were also read by—

Dr Miall—*On the Melting Points of Bodies.*

Professor Mallet—*On the Atomic Weight of Aluminium.*

Dr Gladstone read some notes:—First, *on Explosive Potassium.* Second, *on Froth.* Third, *on the Decomposition by Heat of certain Ammoniacal Salts.* His remarks, particularly on the second subject, gave rise to a long discussion as to the importance of discovering some method of remedying the inconvenience caused by the froth in certain fluids used for the purpose of photography. It was stated that froth did not depend upon the state of the fluid, for it was found even when it was very viscid. In using collodion there was little inconvenience caused by the presence of froth, whereas it was very great in any substance in which albumen was used.

Dr Odling communicated a paper by Mr E. Riley *on Fused Cast-Iron.*

Professor G. Wilson read a paper *on the various Processes for the Detection of Fluorine in any Substance.*

Professor Hodges read a supplementary report *on the Process Employed in the Preparation of the Flax Plant for Textile Purposes.*

Professor Voelcker *on the Methods of Analyzing the Superphosphates*, which elicited some discussion upon the value of having careful and accurate analyses made of artificial manures.

Dr Gladstone read a paper *on the Decomposition by Heat of certain Ammoniacal Salts in Solution.*

Mr Alphonse Gages, curator of the Museum of Irish Industry, read a paper *on some Arseniates of Ammonia.* After mentioning the arseniates of ammonia already described by Berzelius and Mitscherlich, and noticing the doubtful character of the description given in books about the processes for preparing the salts of ammonia and arsenic acid, and the doubtful character of their constitution, he then described his own experiments, in which he verified the constitution of the salts mentioned by Berzelius and Mitscherlich, showing, however, that the salt containing three equivalents of ammonia described by the former contains seven equivalents of hydrated water. He described three new double salts, formed by arseniate of ammonia, in which soda, potash, &c., act as the second bases. He also exhibited some beautifully-crystallized compounds of arsenic acid, with morphia and quinine, which may probably be of interest as therapeutical agents.

Dr Woods, *on the Time required by Compounds for Decomposition.* This contains many points with reference to the conditions which influence the intensities of electric currents arising from different chemical actions, and subjected to the same amount of resistance. The heat absorbed in the decomposing part of the cell was shown in all the instances to be the same in equal times, so that the decomposition, and consequently the intensity of the current, is inversely proportional to the quantity of heat required for the decomposition of an equivalent of the substance used in each case. Other important results, and some predictions which Dr Woods had already had an opportunity of verifying, were also brought forward in this paper.

Dr Lee communicated a paper by the Rev. J. B. Read, *on a New Method of Forming Ammonia Iodides of Metals.*

Dr Odling and Dr Dupré *on the Presence of Copper in the Tissues of Plants and Animals.* The authors had made more than 100 examinations by a great variety of processes, and had recognised the presence of copper in nearly every instance. In several specimens of wheat grain and of human viscera the amount of copper had been estimated. From 100 grains of wheat-ash the authors had obtained 251 thousandths of a grain, and from a sheep's liver rather more than one-half a grain of oxide of copper. The process was to precipitate the copper electrolytically on a platinum wire, to dissolve in nitric acid, and to ignite the residue of the evaporated solution.

Professor W. B. Rogers communicated a paper by Dr A. A. Hayes *on some Modified Results attending the Decomposition of Bituminized Coal.*

Professor Sullivan *on the Solubility of Salts at High Temperature, and on the Action of Saline Solutions on Silicates under the Influence of Heat and Pressure.*

Dr Odling read a paper *on the Effects of Alum in Panification.*

M. L'Abbe Moigno read a paper *upon Three New Electrotype Processes,* and exhibited specimens of considerable interest. The first of these improved processes consists in the employment of platina wires instead of copper, and of making a skeleton figure resembling roughly the outline of the cast sought to be obtained, by means of which, according to M. Lenoir's process, busts, statues, and groups can be produced in full relief by a single operation. The second of these consists in M. Oudrey's process for galvanizing or coppering iron and cast-iron to any thickness required without the cyanide bath. He added remarks upon its employment in commerce and in the navy. The process was not fully communicated, as it is commercially desirable to keep it a secret, but sufficient was communicated to show that the cyanide bath, which is not only expensive but dangerous, can be dispensed with, and that the present system, according to which there is a great waste of material, is avoided, although the substance that is placed upon the iron to induce the deposit of the copper is not stated. The last branch of the paper treated of Messrs Christofe and Bouillet's process for strengthening electrotypes, the principle of which is to leave an opening in the back of the thin electrotype obtained by precipitating, and to put into it various little pieces of brass, which, on being melted with an oxyhydrogen blast, become diffused all over the interior surface of the copper without injuring it in any way, and thereby impart to it the strength of cast-iron.

M. l'Abbe Moigno also presented, in the name of M. Bertsch, microscopic photographs; in the name of M. Bingham, improved photographic copies of oil paintings; and in the name of M. Niepsce de St Victor, a perfectly new method of exhibiting, by means of photography, the phosphorescence and fluorescence of bodies.

Dr Gladstone regarded the photographic experiment to which he had just referred as of the greatest importance to art; for it might be regarded as in some degree tending to throw light upon the hitherto unsolved question of what became of light which had struck an object, and become either absorbed or changed.

Dr DAUBENY exhibited some *Specimens of Paper which had been converted into Parchment.* The discovery, he believed, had originated in the experiments made in connection with the manufacture of gun-cotton, as it was accidentally discovered, when dipping paper into nitric acid, that the same effect was not exercised upon it as upon the cotton, but it was rendered tough. The alteration visible in the conversion of common paper into parchment after being dipped into weak sulphuric acid, is believed to be attributable to the substitution of an atom of water for an atom of hydrogen.

Mr SYKES read a paper *on the Preservation of Albumenized Collodion Plates.*

Dr BARNES and Dr ODLING read a paper *upon the Condition of the Thames Water, as affected by London Sewage*, and said it was now established that the pouring in of the contents of the drains did not affect the water as seriously as was thought. The organic matter of the Thames was chiefly in a state of vitality, and therefore there was not so much putrefaction as was generally supposed; at high water there was the greatest, and at the ebb tide the least amount of organic matter.

Professor W. K. SULLIVAN, Ph. D., read a paper *on the Method of Determining the Nitrates of Plants.* He pointed out the great importance of finding a process for the purpose, because, in determining the amount of nitrogen in plants by the usual processes, a part of the nitrogen of the nitric acid is included in the result, and consequently the true amount of assimilative azotic principles cannot be deduced from ultimate analysis, if nitrates be present. The chief feature of the process is the use of sulpho-vinate of silver to precipitate the vegetable acids, the silver salts of which are insoluble in absolute alcohol, while the nitrate of silver is soluble. He also pointed out a method of separating lactic and acetic acids from one another when present.

Mr G. C. FOSTER read a paper containing *Suggestions towards a more Systematic Nomenclature for Organic Bodies.*

Sir J. MURRAY read a paper *on the Choice of Annual compared with Perennial Fertilizers.* He had to submit to the Chemical Section the comparative value of fertilizers, which were found too soluble on their flooded lands, or in wet seasons, as compared with a chemical manure, now first manufactured purposely as such, which remained almost insoluble until the required display of its constituent ammoniates and phosphates were liberated, at such times and in such quantities as the nourishment of green crops and the ripening of grain demanded. Although he was the first to apply dissolved bones and bone-earth, and he produced luxuriant crops by vitriolized bones forty years ago, notwithstanding his being the originator of that agricultural improvement, yet he felt that the soluble phosphates were too soluble; that they melt very fast in a rainy climate, and run into subsoil below the mould, or were carried off in floods and rivers. The same objection in some degree applied to salt of ammonia. After many years' experience in the north, and on his experimental fields near Dublin, as also by a long series of experiments carried out for him by Mr Brabazon, the gardener of the Richmond Lunatic Asylum, and by Mr Wrigly, the governor, from 1835 to 1842, he felt more and more the conviction that the above principal qualities of manures should be consolidated and locked up, like a magazine of manuring elements, to be liberated little by little, and month by month, as the crops, seasons, and times of germination, and the formation of heavy ears of grain, demanded suitable supplies of ammoniacal and phosphatic imbibition. Aware that double phosphate of ammonia and magnesia were found in calculi and secretions, and in the deposits of pigeons and other animals, and that this salt retained its constituent principles until acted upon by degrees by some common acids, he recommended parties to set about an artificial factory of a salt, so sparingly furnished by nature, and which hitherto was only shown as a specimen in the collections of chemical professors. He now laid before them some of the precipitate or double phosphate of ammonia and magnesia. The result of its composition and use were—first, a triple salt or precipitate composed of equal parts of phosphate of ammonia and phosphate of magnesia. This compound of the chief elements of real guano is fortunately so insoluble that it will remain long in the tanks or lands. Yet, when young turnips or early germination of other crops require fast feeding, the farmer can dissolve any reasonable proportion of his triple phosphate by sprinkling over the lands or middens a little muriatic acid, mixed in any light dust, or in water or sewerage. This acidulous solvent will render plenty of triple phosphates absorbable in plants, and will enable the young crops to imbibe all they can take, and to reserve the residue for a succeeding growth. Wheat and other grains need little or no phosphates till they begin to perfect their seed when ripening. Turnips want phosphate constantly for five months; but evanescent superphosphates of lime, which were like sugar in the first rains, will not wait nine months to enrich the ears of corn, nor will it stay five months to give a daily meal to turnips or potatoes. It was a better plan to lay on the land more lasting food. Ammoniacal and phosphatic salts are evanescent, if not preserved in more durable combination with a more permanent fixant than any hitherto applied by art. Having alluded to means which all farmers can use to save the waste of animal and other emanations about their tenements, he would place before them a sample of the dried-up generator of triple phosphates wherever this dried-up, acidulated, and bicarbonated alkaline powder can meet with ammoniates and phosphates. It arrests them, and locks them up in a magazine, from which none of them can escape until a little sprinkling of cheap muriatic acid renders them obtainable by degrees.

Mr R. L. Johnson then read a paper *on Illuminating Peat Gas.* He stated that it is now nearly half a century since a Parliamentary Committee appointed by Government to report on Irish peat named the town of Sligo and the Hill of Howth as the extreme points of a straight line, and Galway and Wicklow Head as the extreme points of another straight line, between which two straight lines lay the six-sevenths of all the peat in Ireland, the remaining one-seventh being distributed throughout localities on either side of these lines. Having named the different localities where peat is distributed, the total number of which in acres appears to be three millions, Mr Johnson entered into a detailed description of the mode by which he obtained illuminating gas from common peat or turf, which he produced by the double decomposition of the constituents of the peat. He stated that works for the production of the gas have been recently erected, and are in actual operation in two places in Ireland. The gas produced was good, and its cost, as stated to him by a gentleman who was using it, less than two shillings the thousand cubic feet. He stated that from one single pound weight of common peat an hour's light may be produced, and that its cost being so very small, it should ultimately be extensively used throughout Ireland, and in its production there was one-third of charcoal.

Professor Sullivan corroborated Mr Johnson's statement, and said that he saw the gas produced when the experiments were going on, and that it appeared good; and from what he had seen and heard from men who gave the study of peat considerable attention, Mr Johnson had succeeded in producing a cheap and good light from a heretofore valueless though abundant source.

Dr Rawdon M'Namara read a paper *on Coloured Confectionary*, in which he drew the attention of the Section to the large quantity of highly poisonous colouring matters employed in the manufacture of confectionary. He referred to cases of deaths resulting from this practice. He then alluded to the manner in which these substances are coloured by vegetable colouring materials of a harmless nature, and suggested that a list of such colours should be compiled by parties competent to the task, from which alone confectioners should be permitted to select their colours. He gave a sketch of such a list, and exhibited some beautifully-coloured confectionary, in which such colouring matter had been detected. These confections he had for some time in his possession, and their colours did not appear to have faded. In conclusion, he cautioned the public against buying any confectionary in which green or blue colours exist, as such colours are probably produced by poisonous agencies.

Mr Alphonse Gages read a paper *on the Specific Gravity of that extremely dangerous compound, Chloride of Nitrogen.* He gave the determinations, which were extremely close to those given many years ago by Sir Humphry Davy. He also mentioned the fact that chloride of nitrogen dissolves in absolute alcohol without decomposition, but if the solution be allowed to stand for a few hours, it decomposes; and others may probably afford a means of determining accurately the composition of this interesting body. He described an apparatus for introducing the chloride of nitrogen into the alcohol, and mentioned the character of the reaction which took place.

Mr Jasper Rogers read a paper *on the Properties of Carbonized Peat Moss, in its uses Chemically and Medicinally.* Its value medically he elaborately pointed out, especially in all the cases of indigestion, dyspepsia, &c. But he specially drew attention to the value of the preparation as a means for preventing infection from the dead and the evils of decomposition after burial. He pointed out the means by which it might be used.

Professor Cameron read a paper *on Urea as a direct source of Nitrogen in Vegetation.* He showed that nitrogen was also available as food for plants, when a constituent of urea, as in its ammoniacal combination; or, in other words, that urea, without being converted into ammonia, may be taken up into the organisms of plants, and there supply the necessary quantity of nitrogen. He described the experiments which led him to this conclusion, which were very elaborate, and were made on barley plants in confined spaces supplied with air freed from ammonia. The following conclusions were deducible from the results of his experiments, viz:—1. That the perfect development of barley can take place, under certain conditions, in soil and air destitute of ammonia and its compounds. 2. That urea in solution is capable of being taken unchanged into the organisms of plants. 3. That urea need not be converted into ammonia before its nitrogen becomes available for the purposes of vegetation. 4. That the fertilizing effects of urea are little if at all inferior to the salts of ammonia. 5. That there exists no necessity for allowing drainings or other fertilizing substances containing urea to ferment, but that, on the contrary, greater benefits must be derived from their application in the recent or unfermented condition.

Mr J. W. Rogers read a paper *on the Chemical Properties of the Potato, and its Uses as a General Article of Commerce if properly manipulated.* The object of the paper was to show that the matter of the potato was in reality equal in nutritive value to the dry matter of wheat, whilst the quantum of food produced from a given quantity of land was nearly four times that produced from wheat. He exhibited some very interesting specimens of the production of the potato in meal, flour, &c., and gave the following results of analysis :—

	Starch.	Gluten.	Oil.
Components of the potato per cwt.,	84,077 lb.	14,818 lb.	1,104 lb.
Do. of wheat, . . .	78,199	17,536	4,265

And gave the following important fact as to the quantum of food from an acre of land :—

	Starch.	Gluten.	Oil.
Dry matter of potato, . .	3427 lb.	604 lb.	45 lb.
Dry matter of wheat, . . .	825	185	45

Mr Patrick then read a paper *on the Composition of the Iron Ore of the Leitrim Coal Field, with some remarks on the advantages of that district for the Manufacture of Iron.*

A paper by Dr Lloyd *on the Purification of Large Towns by means of Dry Cloacæ* having been read,

The concluding communication was made by Dr Gilbert, being *a Preliminary Notice of Researches on the Assimilation of Nitrogen by Plants, by Messrs Lawes, Gilbert, & Pugh.* The great importance of settling the question, Whether or not plants can assimilate the free nitrogen, of which the atmosphere to such a great extent consists? was first insisted upon. In a purely scientific point of view the question was of high interest, and if answered in the affirmative this would add a very striking fact to the history both of nitrogen itself and of the vegetative functions. A true theory of many agricultural facts and practices also required a definitive solution of this debated point. Earlier writers supposed that the free nitrogen of air could be taken up by plants. De Saussure and others came to an opposite conclusion; and this latter view had been pretty generally adopted by scientific observers. Boussingault in particular had brought experimental evidence to show that plants did not assimilate the nitrogen of the air. But during the last few years a most elaborate and extensive series of investigations had been made by M. G. Ville of Paris, the results of which led him to conclude that plants assimilated a considerable amount of free nitrogen. M. Boussingault had followed up the inquiry in various ways, and still maintained the opposite opinion. It was hence of the highest importance that a third party should undertake the subject, and it was to this end, and the results so far obtained, that the authors brought their plan for discussion before the Section. They described the several methods adopted by MM. Boussingault and Ville, and then illustrated by drawings their own methods and results. In all cases the plants were growing in soil and atmosphere destitute of all combined nitrogen in the first instance. To some, however, as their growth seemed to indicate the need, small and known quantities of ammonia were added. Drawings of the progress of the plants showed an enormous increase of growth where the ammoniacal supply was given. In these cases the plants promised to yield seed, and their height and general development was pretty natural. In the other instances, owing to the combined nitrogen of the seed sown and the free nitrogen of the air, the plants were exceedingly small, and withered before coming to perfection. The final result could not, however, be known until the growing plants, the soil, and the pots in which they grew, were analysed, when the debtor and creditor account, so to speak, of the nitrogen could be made up. Other researches were also in progress to determine the relation of the gases evolved during the growth of plants, to the constituents actually assimilated.

In the discussion which followed, the President and Professor Daubeny took part; the latter gentleman expressing his satisfaction that the question was now taken up by some third person, and it was being conducted on such a considerable scale, and at Mr Lance's Observatory; for he had read with some surprise the apparent sanction given by the Institute of France to the opinions of M. Ville, which so many scientific considerations would lead us to hesitate in adopting.

After further remarks from Dr Gilbert, Dr Pugh, one of those associated with him in the inquiry, entered into further explanations illustrating the methods adopted and the difficulties and sources of error to be overcome or avoided.

SECTION C.—GEOLOGY.

Mr JUKES described so much of *the One-Inch Geological Map of Ireland* as is published, or is on the point of publication, mentioning the maps of the counties of Wicklow, Wexford, and Waterford, and parts of the adjacent counties from Dublin Bay to Cork Harbour, and entering into some details as to the geological structure of the country.

Mr E. WOOD, F.G.S., read a joint paper by Professor De Konnick and himself, *on a New Genus of Crinoids from the Carboniferous Rocks near Richmond in Yorkshire*, all of which have been discovered by Mr Wood. They are very remarkable, inasmuch as the stems of all the species are much thinner at the base than at the summit, probably proving them to be unattached, and floating free on the water. The paper was illustrated by some large drawings and a splendid series of specimens.

Mr FOX read a report *on the Temperature of some Deep Mines in Cornwall*, and gave a tabular statement of the result of his observations. He said, that in the case of Tresarcan mine the depth had been increased 540 feet between 1837 and 1853, and the temperature had increased 8°5 in the deepest level, or in the ratio of 1° in 63·5 feet. Mr Fox drew attention to these numbers as among the most interesting facts which had come under his observation.

Sir R. I. MURCHISON *on the Quartz Rocks, Crystalline Limestone, Micaceous Schists of the North Western Highlands of Scotland proved to be of Lower Silurian Age, through a recent Discovery of Fossils by Mr C. Peach, by Sir R. I. Murchison, F.R.A., and with a Note on the*

Fossils by J. W. Salter, Esq. F.G.S. The opinion stated by Sir I. Murchison to the meeting in Glasgow, as to the age of the above rocks, had been confirmed by Mr Peach's discovery of fossils in them similar to those found in the "calciferous sand rock" of America, which immediately overlies the Potsdam sandstone. This is in harmony with the fact of American types appearing in the lower silurians of Scotland and Ireland, which are not known in England and Wales. The author was confirmed in his belief of the probable lower silurian age of the mica schists, quartz rocks, and altered limestones of Connemara.

The Rev. Mr Symonds remarked that Hugh Miller searched for fossil fishes in the nodules from a rock, coloured as old red sandstone, in the island of Skye, but he was evidently inclined to rank them as lower beds. Sir R. I. Murchison's idea of these rocks is, that they are lower silurian, or perhaps Cambrian, and in this Sir Roderick differs from Professor Nichol. As far as the fossils go, the rocks belong to the lower silurian age, but the fossils are rather obscure. Hugh Miller probably would have now agreed with Sir Roderick on the point to which this paper refers, viz., the physical position of the quartzites of West Scotland.

Mr Forbes confirmed Sir R. I. Murchison's ideas, as he finds traces of favosites in the rocks on the west coast of Norway which are as completely mica schists as those found in the north-western Highlands of Scotland.

Mr Jukes corroborated Sir Roderick's views, as the rocks on the north-west of Ireland are in the same strike as those of the north-west of Scotland. In Galway there were in the mica schists limestones containing nodules in which would probably be found similar fossils. One fact connected with the junction of these beds is, that the upper rocks contain angular fragments of the lower already converted into mica schists.

Colonel Portlock made some observations on the great importance of studying local geology thoroughly as the only means to enable the geologist to generalize on a larger scale.

Professor Haughton exhibited some specimens of *fossil stems from the yellow sandstone of Hook Point, County Wexford*. One of the specimens exhibited a singular structure, the central column being placed near the outer edge, and twining round the stem in a spiral manner. All the other stems shown contained the central vascular bundle in its usual position. He considered these plants to be closely allied to stigmaria found in similar deposits in Donegal and Mayo.

Professor Phillips wished to express his obligations to Mr Haughton for the interesting facts he had laid before the Section. He conceived it highly probable that Mr Haughton's specimens, the spiral structure, may be due to a climbing plant surrounding another, and that in fact there are the remains of two plants in the fossil. There were climbing plants found in the coal measures. Professor Phillips thought it possible that further examinations of other specimens would enable Professor Haughton to add further discoveries in regard to the curious structure in question.

Professor Harkness read a paper *on the Records of a Triassic Shore*. The area occupied by the trias strata referred to occurs in the north-west of England and the south of Scotland. The deposits which form this series consist of argillaceous strata and sandstones, and these beds have their surfaces marked by ripples, which have resulted from the action of the wind on shallow water. Ripples of another character also occur, and these have been produced by the influence of small rills traversing a muddy shore. Tracks which have originated from the wanderings of crustaceans likewise make their appearance on the surface of the sandstone, and with these are found associated the sinuous tracks of annelids, as well as the pitted hollows which form the entrances into the burrows of these animals. Pseudomorphic crystals of salt are also exhibited in the state of small pyramidal elevations on the under sides of the sandstones, affording evidence of natural salt-pans on this triassic shore. Small pittings mark in many instances the faces of the sandstones, and the surfaces reposing upon these pitted faces manifest little dome-like elevations. These have arisen from the effect of rain-drops, in most instances of a small size, resulting from fine rain; in some instances, however, oblong impressions make their appearance, and they are the results of heavy drifting rain. All the physical conditions on these ancient shores are such as we find under favourable circumstances on the sandy and muddy coast of our present seas.

The Rev. W. S. **Symonds** read a paper *on a New Species of Eurypteras from the Old Red Sandstone of Herefordshire.* This fossil was discovered by the parish clerk of Rowlstone, Herefordshire, and presented to the Rev. W. Wenman. Mr Symonds examined the correlation of the rocks in which the fossil was found, and stated that they were gray sandstones of the upper cornstones, and pass upwards into red and chocolate coloured sandstones and the old red conglomerate.

Professor Phillips noticed the interesting nature of the problem connected with the discovery of this new fossil in a rock immediately succeeding the upper silurian rock containing peroxide of iron. The author had proved the continuance of organic life in a series of rocks probably two thousand feet higher than had hitherto been found in the particular geological period to which his paper referred.

Mr **Du Noyer** read a paper *on the Junction of the Slates and Granite of Killiney Hill, County Dublin.* He called attention to the way mica schist and granite were intermingled with each other near their line of junction, giving them the appearance occasionally of interstratification, but showing that this appearance was fallacious, and was the result of masses of the mica schist being caught up in shallow hollows of the granite, and dipping down into them, as if passing under some of the projecting tongues of granite. He also called attention to some curious arrangement of the mica in portions of the granite adjoining the slates, and brought forward some interesting facts relating to the veins of granite and eurite traversing both the granite and the slates.

Signor **Pisani** of Lucca, read Professor Meneghini's paper *on the Recent Advance of Palæontological Research in the Tuscan Territory.*

Colonel Portlock made a few observations upon it. The eruption of igneous rocks at successive epochs has introduced much local variation in the deposits, and so remarkable have these eruptions been, that Professor Meneghini and other Italian geologists have shown that it is possible to arrange them in a chronological order in reference to the stratification. Notwithstanding the difficulty consequent on these eruptions, the true sequence of the whole series of sedimentary rocks, from the bottom of the secondary to the recent alluvium, has been now established. The interest of these determinations increases as we approach the more recent epochs; and two important facts should not be overlooked, viz., the remarkable physical coincidence of the cretaceous and tertiary limestones, combined with the distinctive character of their fossils; and, secondly, the recurrence of the same fossil forms and of the same physical conditions.

Dr **Griffith**—*Notes on the Rocks below the base of the Carboniferous*

Rocks of Ireland. He said these rocks occur in three districts in the north, viz., at Pomeroy, at Curlew Mountains in Sligo, and at the Croaghmoyle Mountains in Mayo, and in one large district in the south, viz., in Cork and Kerry. He concluded by stating that he considered he was justified in calling these rocks silurian, and therefore introducing different letters and columns on his map.

Professor JUKES read a paper, the joint composition of himself and Mr Du Noyer, *on the Geological Structure of Dingle Promontory.* The object of this paper was twofold:—1st, To describe the very curious structure of the Dingle Promontory, comprised of upper silurian (Wenlock and Ludlow) rock on the extreme west of the promontory, overlaid by rocks 10,000 or 12,000 feet thick, called Glengariff grits and Dingle beds, chiefly green and purple grits and conglomerates, with red slates and some calcareous bands (cornstones). 2d, To point out the bearing of these facts on the nomenclature of these rocks.

Mr SLATER, *on the Fossils of the Dingle district.* The author stated that the Wenlock and Ludlow formations were both present at Dingle, each well developed, and bearing a great resemblance to the similar beds in Great Britain, with, however, some difference in the distribution of the fossils. The author also drew attention to the fact that this is the only upper silurian district in Ireland,—that of Uggool, County Mayo, being rather the uppermost beds of the great Llandovery or Mayhill sandstone series, so fully developed in Connemara.

Professor Phillips said, that about fourteen years ago he had spent three days in the Dingle district, and could say from his researches then, and by what he had since read and heard, that the subject presented many and great impediments to the acquirement of a sound and satisfactory conclusion. In his opinion, the beds discovered by Mr Jukes should be called the "Dingle or Glengariff" beds, and not "Devonian."

Professor J. R. MALLET exhibited the *Section and Geological Map of the State of Alabama*, recently prepared by the late Professor Tuomey, to accompany his Report on the State Survey. The principal geological features of the country were noticed, and the resulting peculiarities of soil and economic advantages briefly alluded to.

Professor PHILLIPS then read his paper *on the Ironstone Bands in the Oolites of Yorkshire.*

Mr JAMES YEATS exhibited a *Fossil Cone*, probably from the *Green Sand Formation*, and explained the appearances, which proved that it belonged to the proper coniferæ, illustrating his statement by producing specimens of cones belonging to the cycadeæ.

Mr A. B. WYNNE next read a paper on a section taken in a north and south direction across the Galtee Mountains, in the south of Ireland.

Mr O'KELLY called attention to and exhibited *a Section across Slievenamuck*, south of Tipperary, where there is an east and west vault, with a throw of at least 5000 feet, which brings the coal measures abutting against the silurian.

Mr G. H. KINAHAN read a paper *on the Igneous Rocks of Valentia*, which are found in the old red sandstone formation and ocean, of several distinct characters, the most largely developed being a greenstone, which occurs in more than one locality, as well on the island of Valentia as on the mainland.

Professor W. B. ROGERS read a paper *on the Discovery of Paradoxides in New England.* This fossil was discovered in a quarry near Boston, which had been open for thirty years without its being suspected by men of science that the rock was fossiliferous. A specimen which Professor Rogers had succeeded in tracing to that quarry had been lying in a museum for many years. It had been named *P. Harlanni*, and was supposed to be a foreign specimen. These rocks lie between great ridges of igneous rocks running along the eastern margin of the state of Massachusetts, and although greatly metamorphosed, they exhibit very good specimens of Trilobites. The parodoxides is a fossil found at several localities in Europe, and always in the lowest fossiliferous beds. Some specimens from Boston appear to be very similar to *P. Spinosus* of Barrande, which species is abundantly found in all the lower beds of Bohemia. It is therefore important as determining the age of these New England rocks. Up to the present time the oldest fossiliferous beds in the district in which these fossils had been found were beds containing coal plants. These, however, are separated from the beds near Boston by a large mass of igneous and metamorphic rocks. Professor Rogers remarked that the discovery of these fossils confirmed the idea, that during the earlier geological epochs there was a more general uniformity in the distribution of organic life than is at present the case. A series of exquisitely executed photographs of the specimens referred to were exhibited.

Mr Robert Mallet produced his *Fourth Report upon Earthquake Phenomena*, in abstract, under three heads, the first head gives—*First*, the discussion of the British Association Catalogue of 6000 earthquakes, by curves representing the distribution in time,—(*alpha*) for all historic duration, (*beta*) for seasons, (*gamma*) for months. *Secondly*, the distribution in space over the earth's surface. The important conclusions are—*First*, that the intensity of seismic forces is, in long periods, uniform or invariable; *secondly*, that it is paroxysmal; *thirdly*, that there is a real preponderance during the winter season in each hemisphere respectively. As to distribution in space: The spot on the earth's surface which suffers most seismic disturbance is the island of Luzon in the Indian Archipelago. The *second head* of the Report referred to is the construction of seismometers, in which the author described the various sorts of instruments that had been proposed at various periods and by different persons, and mentioned their defects. The first instrument consisted merely of a bowl of treacle, the motion of which, and the line which was marked upon the side of the vessel, indicated the direction and force of the shock. An Italian invented another contrivance almost equally rude. It was a bowl containing quicksilver, and having eight spouts projecting from the edge. The shock was shown by the particular spouts out of which the mercury was cast. Mr Mallet having alluded to the inherent difficulties of the subject, described the principles of the new seismometer, which he proposed as best meeting the conditions in the present state of our knowledge. It consists essentially of four heavy balls propelled along slightly inclined planes in paths whose directions are those of the four cardinal points, with means of determining in time the paths that they described as due to a given disturbance of the whole system. Under the *last head* Mr Mallet described the work already done and the state of the experiments upon the rate of wave transit in the rocks of Holyhead, taking advantage of the great blasting operations in progress there, in which as much as eight tons of gunpowder is sometimes fired at once. The shock was so great as to be felt at a distance of two miles, and even to throw crockery off a shelf at a distance of eight miles. The length of base over which the transit is measured is nearly a mile (4486 feet), and has been trigonometrically measured with scrupulous care.

Mr Austin observed that an illustration of the elasticity of the earth's surface was afforded some years ago upon the occasion of an explosion of gunpowder at Hounslow. He was himself distant thirty miles from the place at the time, and yet felt the shock of it. At a distance of forty miles from the spot a gentleman happened to be seated in his gig conversing with another. The latter had one foot on the step and the other on the ground, and remarked to his companion that he felt some movement of the earth beneath his foot. This he felt five times, and, taking out his watch, he noted accurately the time when he felt the shocks. On the very same day, at three o'clock in the afternoon, a paper which was published at Lewes stopped going to press, and next day had a notice to this effect:—"Just as we were going to press yesterday five slight shocks of earthquake were felt at this place," naming the time at which the explosion occurred. He himself at a distance of thirty miles felt the earth wave, and also heard the air wave; but the gentleman who felt the shock at the gig told him that he heard no sound whatever, but merely the passage of something beneath his feet. He believed that Lewes was distant from Hounslow about ninety miles, a remarkable distance for a wave to be propagated from so simple an occurrence as the explosion of a mass of gunpowder.

In answer to an observation from a gentleman in the body of the room.

Mr Mallet alluded to the earthquake of Rio Gambia, where the shock came up perpendicularly, and shot people into the air to the height of 100 feet.

Professor Haughton suggested a means by which Mr Mallet's observations upon granite rocks might be made instrumental to the ascertaining of the horizontal velocity of the earthquake wave, and the point from which the shock proceeded.

Mr SORBY, *on some facts relating to Slaty Cleavage.* Mr Sorby states some conclusions which had presented themselves to his mind regarding the ultimate structure of slate rocks, showing that two orders of structure are detected by the microscope—one referable to pressure on a plastic, the other to pressure on a partly rigid body. He mentioned the systematic presence of mica, varied by quartz, in certain slates, and stated his view of the origin of these two minerals by metamorphism from felspar clay. Experiments on the effects of pressure on plastic and rigid materials were given, and a tabular view of two varieties of structure due to pressure and metamorphism on rocks originally, not essentially, dissimilar.

Professor KING, *on Mineral and Rock Cleavage.* The principal conclusions he has come to are, that mineral cleavage is a superinduced structure, the same as rock cleavage; and that rock cleavage is due to the same law, modified, that produced mineral cleavage. As regards what has often been termed slaty cleavage, he considers that there are two kinds—a true and a false one; and he has come to the following conclusions. That true slaty cleavage is ordinary rock cleavage affected by compression applied perpendicularly, or nearly so, to the planes of the latter; and that false cleavage is simply due to pressure applied laterally to the horizontal direction of its planes.

Professor Haughton exhibited a model illustrative of his views on slaty cleavage, and adduced arguments in support of the mechanical theory.

Professor H. D. Rogers disagreed, and pointed out great difficulties which the advocates of the mechanical theory would have to encounter.

A long and interesting discussion followed.

Professor HARKNESS, *on the Jointings and Dolomitization of the Lower Carboniferous Limestone of the County of Cork.* The district around Cork consists of a series of hills and valleys, the former composed of Devonian, and the latter of limestone belonging to the lower portion of the carboniferous series. In the latter are joints having three directions; one, the prevailing direction, being north and south, and of the other two, one is almost horizontal, and the other oblique. These joints occur in great profusion in most of the limestone localities; but in certain spots where the limestone is silicious and thin-bedded the jointings are imperfect and the stratification distinct. Among these limestones there are seen in some quarries in the neighbourhood of Cork dykes of dolomite, and then dykes in jointed limestone conforming to the main north and south joints. In the quarries where the stratification is distinct we often find also dolomites, and these agree with the planes of stratification. The production of these dolomites appears to be subsequent to the deposition of the strata in which they occur. From the observations of Regnault, it would seem that sea-water (containing sulphate of magnesia) is capable of exerting considerable influence on limestone, giving rise to carbonate of magnesia and sulphate of lime; and the phenomena exhibited by the district around Cork would lead to the inference that sea-water, finding access into rocks by joints, and in some instances along the planes of stratification, has produced the dolomitic masses.

Dr Clarke read a paper, in which he described *the elevation of an ancient sea-beach of the coast of the county of Waterford*, extending about 2½ miles, and reaching at one part an elevation of 60 feet. He exhibited the cetacean remains found in it, and stated that it was obviously of the past era, though all its fossil shells had living representatives in the adjoining bay; and after comparing its age with the chief shelly deposits in Ireland, as the marls of Wexford and Wicklow, and of Londonderry, he added, that it was perhaps the most recent of which we have geological proof in Ireland. He next described an igneous protrusion (marked in Dr Griffith's map), with a view of fixing the geological age, and describing its effect on the adjoining strata. This rock presents itself in greatest force at Newtown Head, where it reached an elevation of 60 feet. To the elevating influence of this rock Dr Clarke assigned the upraised position of the ancient sea-beach, as it was evident, from the section of the coast exhibited, that the latter formed with the dyke a great anticlinal ridge, whose crest was immediately over the highest part of the igneous rock, and the surface of the beach was everywhere parallel to the trap protrusion beneath. He also remarked, that 200 yards north of the great dyke a smaller one existed, and it too was in the centre of another anticlinal ridge, in the surface of which the raised beach was everywhere parallel. The author then remarked, that as the igneous mass seemed to have upraised the beach, so it must itself be referred to a period during the same era, but antecedent to its close, or to the recent period of Sir Charles Lyell, but at present referable to the former, owing to the absence of human remains or works of art; and as the occurrence of traps in post-tertiary rocks is rare, he considered that the assignment of so recent a date to the igneous protrusion at Newtown Head would prove of interest to Irish geologists. Dr Clarke then described an extensive deposit of peat, four feet under the level of the tide, at a point commencing immediately adjoining the southern extremity of the raised beach. Dr Clark, added, that it would be well if it were generally known that the uncovering of parts of saline peat, and its use as fuel, is attended with danger, owing to the production of sulphuretted hydrogen, arising from the hydrogen of the decaying vegetable matter on the sulphur of the saline sulphate.

Professor Hennessy read a paper, in which he attributed *the changes of the earth's structure to the change of the sea-level at different times.* If the globe had solidified from a fluid state, judging from the appearance in the cooling of fused rocks, we should get a change in the distribution of matter within it. This would distribute land and water in a different manner, and a very small change in the elasticity of the liquid envelope of the globe would suffice to produce great changes.

Mr R. Godwin Austin read a paper *on the Occurrence of a Boulder of Granite in the White Chalk of the South-East of England.* He described the threefold division of the cretaceous series of the south-east of England, viz.,—1. The littoral shingle of the lower greensand at Farrington, in a sea not exceeding ten fathoms. 2. The gault in deep beds over the south-east of England, its littoral beds lying to the west, the Haldon Sands. 3. The area of the white chalk ranged as far north as from the north of Ireland to the Baltic at Riga, and extending to a broad zone over North Germany. In North Europe the conditions of the deposition were remarkably uniform over the whole of the Anglo-French basin; 800 feet is its average thickness, and it is all a deep-water deposit. Rolled shingle and fragments of extraneous rocks have been found in the chalk in many places. They are all of crystalline, mostly of granitic origin. Their size is not considerable, but yet beyond the moving power indicated by the white chalk: the means of transport usually employed to transport materials into great depths are floating seaweed and icebergs. He described the Croydon boulder; it is too large to have been carried by anything but ice. It was found in connection with other similar materials which had evidently been deposited at the same time. These rocks, so assembled, only exist in the Scandinavian mountains; and their being found in this position throws light on the distribution of land and water in the north of Europe as the epoch of the deposition of the chalk; there were these regions lying to the north of the Chalk Ocean, from which the boulders were borne by icebergs and floes, as at the present time. The reason that these boulders are not of more frequent occurrence in the chalk was explained, with reference to the present path taken by the icebergs in the Atlantic. During the drift period of the Pliocene division of geological history the set of the liberated ice was more eastern, dependent on considerations which are well understood, and can be made available for any period.

Professor Phillips remarked that the lump of granite which occurred in the chalk was of a very peculiar kind, and quite different to any of their English granites. It was composed of quartz and felspar, and without mica, in this and other respects accurately resembling the granite of Scandinavia. At the time of the deposition of the chalk the granite of Scandinavia may have been found in part of a range of mountains which extended to the Highlands of Scotland. In the oolitic deposits of Yorkshire the sediment in the rock pointed to some land which may have existed in the neighbourhood of Scandinavia. The late Professor Forbes, in his theory to account for the distribution of plants and animals, proved that there was a connection between the northern portions of Europe and the north of England.

Herr Herman Schlagintweit made some *observations in reference to Erosion and Cleavage*, particularly with reference to observations made by his brother Adolphe, who had paid particular attention to the science of geology during the travels of the three brothers in India. The erosion was said to amount on an average to a depth of 1500 feet in the Himalayas, and is proved to exist by the deposit of rocks and by the spoon-shaped excavations of the sides. Its most important consequences were detailed,—the change in the transporting power of rivers, drainage of lakes, and subsequent dryness of the atmosphere, which, for instance, explains the formation of salt lakes with a general revolution in meteorological conditions. Changes in climate and vegetation have been produced by the appearance of new deep vacancies which did not formerly exist.

These have an influence on currents of air and on the transparency of the air, which is limited in consequence of the currents of air at different temperatures. The chief cause of this erosion is the amount of the irregular distribution of rain in recent geological periods. In the Himalayas there are hardly any lakes. The principal and lateral valleys meet nearly in the same inclination; waterfalls do not exist at all. All this is in consequence of the erosion having there existed to a much greater degree than in Central India or in the Thiarnshan chain of mountains. Besides the mass of water, also the great quantity of suspended mud was pointed out as increasing the erosion. On the subject of the cleavage, M. Schlagintweit pointed out the connection between the intersection of cleavage plains and the position of the poles in magnetic rocks. The apparent parallelism between certain cleavage planes, with the strata of stratified rocks in their divisions, and the several facts which tended to show that in many cases the cleavage planes have been produced by a force which had been decomposed, and resolved in different directions by meeting unequal resistance.

Mr Robert Chambers said—In the valleys of Scotland the glacial drift forms in some places the flanks of the valley, having a narrow channel at the bottom cut out by the existing river. The present river action is therefore not the origin of the valley, which must have been produced under quite a different set of conditions. He attributed it to sea action at different times. He alluded to the fact of the sea having, in many parts of the Scottish coast, excavated caves in the solid rock. When the roof of these falls in, and the land becomes elevated, valleys will be formed. He then proceeded to draw a comparison between the valleys of Scotland and India, and showed that the secondary valleys, or those excavated by means of the existing rivers in India through the solid rocks, were often 1500 feet in depth, though agreeing in a geological point of view with those of Scotland.

Professor Oldham confirmed to the fullest the statements of Herr Schlagintweit. He himself had seen valleys in the Himalayas of recent river formation, the depth of which were fully 4000 feet—those of 1500 to 1800, with perpendicular sides, were common. That such were not formed by sea action is quite evident, the sinuous character being of itself enough to show this. The wonder at the extraordinary power of rain water and river water to produce such an amount of erosion would, perhaps, be lessened when the enormous amount of rain which falls during four months of the year is taken into account. He himself measured thirty inches of rain as having fallen in 24 hours, and the total amount in four months was 600 inches (50 feet).

Mr Hopkins read his *Report on the Conductive Powers of various Rocks.* Mr Hopkins gave an account of the results of numerous experiments which he had recently made on the conductive power of various substances for heat. To explain the objects of these experiments, he stated that if a globe of any large dimensions, like the earth, were heated in any manner and in any degree, and then left to cool by the radiation of heat from the surface, the temperature of the mass at points not too remote from its surface, and after a great lapse of time, would follow a very simple law—the increase of temperature in descending below the surface would be proportional to the increase of depth, supposing the conductive power of the mass to be the same throughout. But if a stratum of another substance (as sedimentary matter, for instance, in the case of the earth) superimposed on the sphere, its horizontal extent being large in proportion to its thickness, the rate of increase of temperature in descending within this stratum would be greater or less than in the other parts of the sphere, according as the conductive power should be less or greater. It would be approximately in the inverse proportion of the conductive powers. The principal object of these experiment was to ascertain whether such be the case or not. The conductive powers of lime, clay, and sand, in the state of dry powder, are in the order in which they are now mentioned; calcareous rocks, from dry chalk to hard mountain limestone, vary in their conductive powers (on the numerical scale adopted) from 1·7 to 5·5 deg.; sandstone rock, from 2·5 to 7·5; granite, and very hard compact felspathic rocks, from 5 to 10. Hence it follows, that if the terrestrial heat observed at present in mines, Artesian wells, &c., be entirely heat transmitted from a central nucleus, the rate at which the temperature increases, as in descending below the surface of the earth, ought to be very different in different formations. It appears, however, that this rate, in known mining-shafts and Artesian wells which have penetrated to the greatest depths and in which the observations are most trustworthy, in different parts of Western Europe, is nearly the same in different formations. The author compared the two cases of the well at Paris and a vertical coal shaft at Tuckenfield, near Manchester. He estimated the conductive power in the former case at one-half of that in the latter; while it was found by observation that there was an increase of one deg. F. for every 60 feet of depth in the former, and for about 64 feet in the latter instance whereas these depths, instead of being in the ratio of 60 : 64, ought, according to the theory, to be at the ratio of 60 : 120. This proves that the temperature observed in these cases cannot be due merely to heat transmitted from the interior of the earth by ordinary conduction. The author stated also that he had investigated the influence of induration, pressure, moisture, and discontinuity on the conducting powers of various substances, referring for details to a paper lately read before the Royal Society.

Professor H. D. Rogers read a paper *on the Geological Survey of Pennsylvania, with Maps and Illustrations.* The author described the difficulties experienced in the execution of this survey, from the absence of accurate maps of the country, which compelled him to execute a partial topographical survey in addition to other work. During a portion of the time the Professor had to carry on the undertaking at his own expense. The paper was illustrated by some very good engravings of the localities and by the geological map of the State, and the methods adopted in conducting the survey were briefly sketched.

General Sketch of the Districts already visited by the Geological Survey of India. By Thomas Oldham, A.M., F.R.S., G.S., &c., Superintendent of Geological Survey of India.

The labours of the Geological Survey of India have been conducted hitherto under great difficulities. More recently, however, the liberality of the Government of India had greatly extended the establishment of the survey, and he trusted that their future progress would be rapid and effective. The only general sketch-map of the geology of India which they had was that published by the late Mr Greenough. This was a work of great value, and gave abundant proof of the extent and labour of its author in its compilation. As might be anticipated under the circumstances, it was full of errors; and perhaps few could speak more confidently of this than himself. But at the same time it was a most valuable contribution, and would prove a most useful guide to future observers. The officer of the geological survey had examined several districts of considerable area in detached positions, and the results which he was able to lay before the section might therefore appear less connected than he could wish. But every day would tend to unite them more closely; and his object was now simply to report progress, and to show that something had been done to elucidate the structure of India. Referring first to the districts to the east of the Bay of Bengal, the Tennasserim Provinces extend for about six degrees of latitude along the east shores of the Bay of Bengal. In breadth they seldom exceed more than one degree of longitude. From Siam, on the east, these provinces are separated by an interrupted range of mountains, occasionally rising to 7000 or 8000 feet high, but the general height of which is to the north about 4000, diminishing in passing southwards to 3000 feet or less. The main direction of this range is north and south: this being also the general direction of the coast line, of the minor and outlying ranges of hills, and, therefore, of the rivers. The geological structure is tolerably simple, although at first sight apparently complicated, from the great disturbances to which the rocks have been subjected. The central range is of granite, occasionally, but not frequently of syenitic character; itself traversed by thick veins of large crystalline felspathic granite, and often along its outer edges, or near its junction with overlying slates, characterized by the presence of tinstone as an ingredient of the mass disseminated among the other mineral constituents. This granite axis is succeeded by highly metamorphic rocks of gneissic and micaceous character, themselves cut up by numerous veins of granite, which, however, do not extend far from the junction. Upon these is a great accumulation of bluish and bluish-black earthy beds, thinly laminated, of thin-bedded grits, and of pseudo-porphyritic rock, the normal character of which is an earthy hard rock with small irregularly disseminated sub-crystalline felspar, passing, on the one hand, into slates, and, on the other, into grits, often coarse and conglomeritic. These harder rocks form all the higher grounds of the outer ranges of hills. This series being best seen in the southern province of Mergin, has been provisionally called the "Mergin" series. The total thickness is about 9000 feet. It is succeeded unconformably by hard sandstones in thick and massive beds, with their earthy partings, generally of reddish tints, occasionally deep red and yellowish. A few beds are slightly calcareous, and in the upper portion a few thin and irregular bands of earthy blue limestone occur. Above these rest about 200 feet of soft sandstone in thin beds, upon which apparently rests the massive limestone of the country so largely seen near to Moulmein. The thickness of the entire group is about 6000 feet, and as some of its members are but seen in the northern province of Moulmein, I have provisionally called it the "Moulmein" series. To determine the age of the older of these two groups (the Mergin) we have no data. The aspect of much of the rocks is very similar to the trappean ashes and felstones so abundant in the silurian rocks of this country, while others are lithologically like Devonian; but these resemblances are very deceptive. The age of the Moulmein series is, however, tolerably defined by its organic contents. These appear to fix the age of the group as distinctly carboniferous. The whole of these rocks were, subsequently to their induration and disturbance, widely and greatly denuded, and on their upturned edges at intervals is found a series of conglomerates and sandstones and imperfectly coherent shales, with thick beds of coal, generally of lignitic character. None of the conglomerates are coarse; the sandstones are fine, gritty, and pebbly, or clean white quartzose grits; the shales thinly laminated; the coal itself thinly disposed in thin flaky laminæ, with earthy streakings marking its structure. In addition to the total unconformity of these rocks, the imbedded organic remains are quite distinct. They consist of dicotyledonous plants (leaves) belonging to the group of the Laureaceæ, and probably to the genus Laurophilum of Goppert. In the thin papery shales which overlie the coal are also remains of fish (scales, &c.) of fresh-water character; the whole referring the beds to a very recent epoch, probably corresponding in part to the pliocene of European geologists. It is curious to notice here the absence of any coal in the carboniferous rocks below, and its abundant presence in those newer beds. The total thickness of these beds does not exceed 900 to 1000 feet. They are never continuously traceable; they occur heaped up against and separated by the projecting ridges of the higher grounds, and must have been deposited when the physical conformation of the country was very similar to that now existing. They appear to be the result of a series of fresh-water deposits, formed in small lake-like expansions along the lines of the great drainage valleys of the country, and to mark a line of general and greater depression between the main ridge of hills dividing Siam from the British dominions, and the outer ridges which occur between this and the sea. The direction of the main drainage of the country is determined, as already remarked, by the direction of these ranges, and is discharged into the sea through narrow rocky gorges, which have a direction nearly east and west, and which are due to lines of breakage and dislocation. To this is due the sudden alteration in the direction of the courses of the larger rivers, as may be seen on maps. Rocks similar to those situated in the Tenasserim provinces extend northwards up the course of the Salween River, and into the adjoining districts of Burmah, to the north-east of Pegu. And, again, close to the capital of Burmah, and stretching nearly north and south, as far as examined, high ridges of metamorphic rocks are again met with, consisting of gneiss, micaceous schists, and highly crystalline limestones, occasionally of a fine white colour, and largely used by the Burmese for sculpture. But the great valley of the Irrawady is, throughout a very large extent of its course, bounded on either side by a thick series of rocks, chiefly sandstones, but with massive limestones also, which are locally rich in fossils, and which, from this evidence, may be clearly referred to the eocene period. These stretch on both sides of the river as far north as Pugahu, beyond which the higher grounds recede from the river banks; but they are in all probability continued thence into Munipoor, and so united with the nummulitic rocks of the Khasi and Cachar Hills. These rocks have been considerably disturbed and broken, but have a general and prevailing strike nearly north and south, which strike, throughout many miles, has determined the general course of the River Irrawady. Their thickness is considerable, certainly exceeding 5000 feet. Above these eocene rocks, and resting upon them with slight unconformity, is a series of beds of no very great thickness, characterized by an abundance of gypsum disseminated in thin layers and veins, and in the lower beds of which occur the deposits of clays and of vegetable matter, from which are derived the larger supplies of petroleum. These rocks are well seen at Senan Kyoung ("stream of fœtid water"), and are traceable northwards to near Amarapura. In the beds which appear to form the uppermost part of this group, but which may possibly belong to another and distinct series, are found some of the fossil bones of the larger animals which occur abundantly in this district. About forty miles north of Amarapura we again meet with sandstones, shales, and coal, resting unconformably on the metamorphic rocks, and characterized by remains of dicotyledonous trees similar to, if not identical with, those found in the coal-yielding group of the Tenasserim provinces, and which are therefore referred to the same age (pliocene). This series, so far as examined, proved of no great extent or thickness. We pass now to the Khasi Hills, which form a comparatively isolated range, rising suddenly from the great plains of Bengal in the south, and divided in the north by the valley of Assam from the great Himalaya or Bhotan range. On the southern face of this range rises almost perpendicularly from the plains, which are continual from the Bay of Bengal, with scarcely a perceptible change of level to the very foot of the hills, and, with the exception of a comparatively small thickness of metamorphic rocks at the base, are composed of nearly horizontal beds of sandstones, a few shaly layers and limestone, long known for the abundance and beauty of the nummulites it contains. These beds dip slightly to the south, and die out towards the north, when the metamorphic rocks come to the surface in the hills. Disregarding here any details as to the older rocks, the age of the sandstones and limestones is unquestionably fixed by their organic contents, and therefore, also, the epoch of the coal, which is associated with them, as belonging to the great eocene period of geologists. No newer group of rocks is definitively seen in these hills. Along the southern face of the range there is evidence of a great dislocation extending for many miles, and possibly along the entire scarp, which has brought down to the level of the plains the rocks which are seen at the top of the hills. This line of dislocation has in all probability tended to give the nearly rectilinear direction of the escarpment; its date is fixed as at least subsequent to the formation of all the eocene rocks here seen. An older group of sandstones, considerably altered, is seen further to the north, within the hills, and also a series of highly metamorphosed schists and grits resting upon the gneissic and granitic rocks; but the details of these are reserved. Passing thence still further to the north and east, at the base of the Sikkim Himalayas, under the hill station of Darjiling, another section was described. The great mass of the lofty hills is here composed of schistoze rocks of various characters, considerably disturbed and contorted. These, although hitherto coloured similarly, and considered as of the same age, were decidedly different from, and more recent than, the gneissoze rocks of the greatest portion of India. Near the base of the hills, and faulted against these rocks at high angles, there is a small extent of sandstone and black shales, which contain vertebrata, pecopteris, &c., similar to those occurring in the great coal-fields of Bengal. These fossils are peculiarly interesting, from the fact of their being changed into graphite, and occurring in beds which themselves have a very strongly marked graphitic character. They are of very limited extent; the greater portion of the sandstones, which in this section exhibit a thickness of some thousand feet, belonging to a series of much more recent date, and which has been subjected to a much smaller amount of disturbance and alteration. The exact relation of these, too, it has not been possible to observe. This upper group contains many large stems, in all observed cases prostrate, and in most cases giving evidence of great wear and long exposure previously to being imbedded; and in some of the finer and more earthy deposits an abundance of leaves occur, of the same general character as those already noticed as occurring in Burmah and Tenasserim. This group was therefore provisionally referred to the same age (pliocene). No traces of the great nummulitic series had been observed in this district. In the more central portions of India three very large districts had been examined, to which he would now refer. One of these was to the south of Calcutta, in the district of Cuttack; the second included all the country between the great coal-field of the Damoodah, which had previously been mapped by Mr Williams, and the River Ganges, extending northwards to Rajmahal and Bhagulpore; and the third extended along the valley of the Nerbudda from west of the Hosungabad to many miles east of Jubbulpur. For the details of the first of these he was indebted chiefly to his able assistants, the Messrs Blandford; for the last to Mr Jos. Medlicott, who had very zealously worked it out, having to carry on the formation of a topographical map at the same time. In all these cases the sedimentary rocks, to which he would refer, formed portions of a series once more widely extended, and probably continuous over the whole country, now separated by denudation, from removal by which they have been in great part protected, by being faulted into and against the highly metamorphose gneiss, &c., which surround them. The Talcheer field extends for about 70 miles from east to west, with an average breadth of 15 to 20 miles, and is bounded both on the north and south by great parallel faults, the former of which has an aggregate throw of upwards of 2000 feet; these faults are not truly east and west, but to the south of east and north of west. The section in ascending order of the basin shows at the base sandstone and blue shale, but slightly fossiliferous in thickness from 500 to 600 feet; over these is a series of shales and sandstones often micaceous, occasional beds of ironstone, and thin layers of coal and coally shale, giving a total thickness of about 1800 feet; and over these again is a distinct series of quartzose grits, conglomerates, and sandstones, in thickness from 1600 to 2000 feet. These three groups are unconformable each to the other; the unconformity between the two lower being, however, much less marked than that between the two upper. To the lower group, as having been first recognised and described in this district, the name of "Talcheer" series has been given; the second group, which, from its imbedded vegetable remains, was proved to be identical with the rocks of the extensive Damoodah coal-field when these were first described, has been denoted the "Damoodah" series; while the upper group, supposed to represent the great series of rocks, so magnificently seen in the Mahadeva Hills of Central India, has been called the "Mahadeva" series. Thus these series can be recognised in each of the extensive fields referred to, although with varying developments and thicknesses. At the base of the Talcheer series there is a remarkable bed, consisting of very large and only slightly rounded masses of granite and gneiss, imbedded in a fine silt, and occurring under such conditions as induce the opinion that the action of ground ice has been the cause of its formation. In the Rajmahal district there is a very limited development of the lower beds, above which unconformably comes the Damoodah series, here exhibiting a greater extension upward than in Cuttack; but unfortunately the sequence of the rocks is interrupted by the intercalation of several successive floes of basaltic trap, the intervals between which have been marked by the continued and tranquil deposition of the mechanical rocks going on. These floes have been repeated six or seven times, and the phenomena of contact are in all cases marked; the upper layers of the mechanical deposits in contact with the trap being in all cases greatly altered, while the lower layers are in no cases changed, but rest unaltered on the degraded surface of the underlying trap. But while the actual physical sequence of the deposits cannot be here traced, the fact of their all belonging to the same great series is attested by the occurrence of some identical fossils throughout. A few species pass upwards through the series, but there is a very marked change in the general facies of the flora in the upper as compared with the lower portion of the group; the latter characterized by the abundance of vertebrata, pecopteris, trizzgia, &c., the former by the abundance of zamia-like plants. The series, therefore, has been divided into Upper and Lower Damoodah rocks. For the details of the structure of the district, reference was made to the maps. In the Nerbudda district the series was less interrupted, and there also the same general results were obtained. The southern boundary of this great field was for a large part of its course produced by a great fault, having, *quam proxime*, the same general direction as that of the faults bounding the Talcheer field. The age, geologically considered, of these Damoodah rocks was briefly referred to. A large series of drawings of the fossil plants from them were exhibited, and the fact of the general oolitic facies of this group, especially of those from the upper beds, pointed out. The difficulty of the question was alluded to, especially in connection with the discovery, on the one side, of several species identical with those found in these Indian rocks in the Australian coal-fields, associated with numerous animal remains distinctly referable to the lower carboniferous era, and, on the other hand, to the discovery in Cutch of other species, also identical with some of these Indian forms, in beds associated with animal remains, undoubtedly referable to the oolitic epoch. It must, however, be borne in mind that the latter forms, or those which the evidence of associated animal remains would show to be oolitic, are only found in the upper beds of the Damoodah series, while those which are common to the Australian fields are those chiefly found in the lower beds. Unfortunately, no animal remains whatever have been found with these plants in the districts examined, excepting some annelide tracts useless as distinctive forms. He preferred, under these circumstances, waiting for further evidence before giving any definite opinion as to the age of this widely-extended and important group of rocks. Mr Oldham then stated that there seemed good reason for separating altogether from the several groups of rocks to which he had referred the whole of the great thickness of sandstones which formed the great Vindhyan range, extending almost entirely across India, from the mouths of the Nerbudda to the Ganges at Monghyr. These appeared to be of prior date, and there was a probability that there was a great line, or a group of lines, of dislocation passing along the general line of the valley of the Nerbudda, and the effects of which might be traced over a very large area, extending towards the north-east, possibly even into the Valley of Assam. Besides the examination of these districts, which together included an area of more than 30,000 square miles, the geological survey had been able to add to the knowledge of the structure of the country in other ways. An excellent selection of fossils from the neighbourhood of Verdchellum in Madras, for which they were indebted to Brooke Cunliffe, Esq., who had been associated with the Rev. Mr Cay in the first examination of these fossils, had enabled them to add largely to the lists of Forbes, and to establish more conclusively than before the cretaceous age of these deposits. The exertions of Captain Keatinge at Mundlaiser, to whom Mr Oldham had pointed out the interest of the inquiry, had collected a good set of organic remains from the limestone at Bang, to the west of Mhow, which had enabled him to fix the age of those deposits as contemporary, or nearly so, with the cretaceous beds of Trichinopoly and Verdachellum. This discovery gives rise to many important speculations as to the age of other beds, and also as to the epoch of the elevation of all Central India, but more data were required before these could fairly be entered upon.

Mr W. H. Baily, *on the Carboniferous Limestone Fossils from the County Limerick.* The fossils described by the author were collected by the Geological Survey; there are several new forms among them, and they are all well preserved. Zoophytes.—Of this class of organic beings, usually so common in carboniferous rocks, there are only a few specimens, chiefly belonging to the division *Zoantharia tabalata* of Milne Edwards, amongst which are the genera Michelenea and Chœtetes; also the common and characteristic coral, *Amplexus coralloides.* Echinodermata.—These are chiefly Melocrinidæ, consisting mainly of detached bodies of Platycrinus and Actinocrinus, almost exclusively confined to this formation. Bryozoa.—Several forms, chiefly Reteporidæ, amongst which are fine specimens of the well-known *Fenestella membranacea* of Professor Phillips. *Brachiopoda-terebratulidæ,* only one species; *T. Hastala,* of which there are fine specimens. Spiriferidæ.—Several characteristic forms, including *Sp. Roemerianus* (de Köninck), a form new to Britain; and *Athyris roissii,* a singular and rare species, in which the lines of growth are developed into expansions, giving it a fringed appearance. Rhynconelidæ.—The common forms *R. pugnus* and *R. pleurodon.* Orthidæ.—The well-known *O. restipinata* and the very rare *O. radialis.* Productidæ.—Several characteristic and rare species, including *P. aculeatus* and a new species. Chonetes.—Several rare varieties, as *C. Koninckii,* new to Britain; *C. variolata* (D'Arbigny); *C. papillionacea.* Conchifera.—Several new forms, including species of the genera Aviculopecten and Pteronites (M'Coy), shells having an oblique axis like the so-called pectens of the coal measures. Of the singular shell *Conocardium Hibernicum* (Pleurorhgynchus of Professor Phillips), there are several good specimens, showing the extended keel and siphuncle in some species still more extended, being analogous (as suggested by Mr Woodward) to those of cockles inhabiting salt inland seas, as Lake Aral and the Caspian. A second species, *C. Koninckii,* of which several very perfect specimens were found, contains even a larger size than *C. Hibernicum.* Professor De Köninck agreed with the author in considering it an undescribed form. He proposes to call it after that distinguished palæontologist. There are several species of Cardiomorpha, one of which, *C. Koninckii,* is new to Britain, and another, a new species of large dimensions. Gasteropoda.—Many genera and species, including a new species of Macrocheilus and other undescribed forms. Of the Nucleobranchiata, supposed to be allied to existing floating shells, several species of Bellerophon, together with *Porcellia puzio,* a very rare discoidal form. Cephalopoda.—This, the most important order of the mollusca, is represented by large and rare specimens, all belonging to the order Tetrabranchiata. Nautilidæ.—Fine specimens; some new. Orthoceratidæ.—*O. muensterianum,* and fine examples of *O. dactylophorum,* with the peculiar forms of *Gomphoceras* (*Poterioceras*) *fusiforme* and *Ptychoceras verneuillatum.* Goniatites.—Several species, including *G. crenistria* and *fasciculatus,* some showing external markings, and others being new forms.

Mr W. H. Baily also read a paper *on a New Fossil Fern, from the Coal Measures near Glin, County Limerick.* This fern was discovered by Mr G. H. Kinahan in the black shale above the coal in the townland of Ballygilternan Lower, County Limerick, together with ordinary coal plants. It appears to be the central portion of a frond, with about 20 alternate pinnules, which are apparently covered by thecæ or cases of the reproductive germs, presenting an appearance somewhat resembling rows of small flowers. This plant is unlike any present or fossil fern, and has organs of fructification—an occurrence rare among carboniferous ferns. It is exceedingly interesting, and may possibly be a new generic form.

Dr Gladstone read Mr G. F. Habershon's *Account of the Barbary Coast, with Fossils.*

Mr J. Birmingham read an abstract of a paper *on the Drift of West Galway and the Eastern parts of Mayo.* The author set out by alluding to the interest and importance of the Irish drifts in general, which are well developed in the district to which his paper refers. They differ from the drifts of other countries by containing no fossiliferous evidence of their comparative date; and to account for the absence of shells or any traces of boring molluscs in their materials, the author suggests that the remains of those great drifts, which are now exposed, probably never formed the surface of the former sea-bottom. He divides the drift of his district into three principal divisions, namely:—1. The Clay Drift, from the south-west, forming cliffs on the north, east, and south shores of Galway Bay; 2. The Great Boulder Drift, from the north-west, overlying the former; 3. The Escar Drift, forming the chains of gravel hills in the interior of the country, and derived, like the clay drift, from the south-west. The direction and sequence of those drifts is inferred from their mineralogical characters and relative position. The perfect round forms of the Escar Hills, and the complete curves their beds or layers exhibit in any stratified section, not only prove their subsequency to the other drifts, but furnish a strong argument against the glacial hypothesis; for, if icebergs had been floating about and grooving the rock-bottom of the shallowing sea, the Escars would scarcely have escaped their action, which would be recognised in the tabulation of their summits or other significant appearances. The long ranges of those gravel hills he believes to be the effect of eddies, as the land approached the surface; and their lines may often show the resultants of currents subdivided from the main stream beyond the limits of opposing hills. He maintains that it is to the power of moving water, and not either to glaciers or floating icebergs, that the phenomena of the drift of this district are to be ascribed. Nothing can be more marked than the regular increase in number, as well as in size and angularity, of the erratic blocks as they are followed towards their source. Their decrease in numbers, according to their remoteness from their parent rocks might indeed be accounted for by the glacial hypothesis, but not so simply their diminished size; for though the ice-raft may waste away by degrees, and its powers of buoyancy become less, still this must be thought to affect the total quantity rather than the individual parts of the load that it bears. As its cliffs succumb in its progress through the warm sea waves, its burden may gradually be reduced; but there is no reason why the largest masses should not be found among the mixed materials which are carried on its contracting area. The striation of the surface rocks, which the author observed in some parts of his district, he considers to have been effected by the pushing forward before the breakers of large flat masses of the stratified rocks of these localities, and referred to the early notice of this subject by our eminent Irish geologist, Mr Griffith.

Frederick J. Foot, Esq., read a paper describing a *Section from Bird Island, at the mouth of the Shannon, to the village of Castlemaine, in the County Kerry.* In this paper Mr Foot described the rocks from the coal measure shale to the upper conglomerate of the old red sandstone. He mentioned that the drift was generally from the north, and that granite boulders (some of them of large size) were frequent in it. The principal points of interest were the conformability of all the rocks described, and the variableness of the conglomerate bed, both in thickness and character. He also exhibited some stems of plants from the yellow sandstone, or upper subdivision of the old red sandstone.

Professor Harkness, after referring to the great services rendered by Professor Sedgwick to the geology of Cumberland, read a paper *on the Geology of Caldbeckfells and the Lower Sedimentary Rocks of Cumberland.* The district alluded to in this communication forms the northern portion of the mountainous area of the lake district of Cumberland. Caldbeckfells, including their eastern extremity Carrickfell, consist of masses of a plutonic and an igneous nature. On the southern slopes of these hills there is seen Skiddaw slate, which generally has a south dip, and this Skiddaw slate, as it approximates the granite of Skiddaw Forest, passes into chiastolite slate, chiastolite rock, and a pseudo-gneiss. On the south side of the granite area the same phenomena occur; but on this side hornblende rock and actinolite rock also appear. In the metamorphic rocks, and likewise in the ordinary Skiddaw slates, which succeed them in position, the strike of the strata is nearly east and west, and the general arrangement of the strata seems rather to indicate that the plutonic masses of Caldbeckfells form the axis of the group rather than the granite of Skiddaw Forest. With respect to the unaltered rocks of the Skiddaw district, these have been referred by Professor Sedgwick to three groups—black Skiddaw slate grits, seen in the masses of Grassmere, and gray Skiddaw slate, containing fossils described in the palaozoic fossils of the Woodwordian Museum. The upper gray slates are the deposits which have hitherto afforded organic remains. Last year the author obtained trails of worms from the black Skiddaw slate, the lowest number of the unaltered series, at Bralkeld; and from a communication which the author had received recently from Professor Sedgwick, it would appear that in these low strata graptolites have been lately obtained by Mr J. Ruthven. With regard to the lithological nature of these Skiddaw rocks, it would seem that there is a considerable change according to locality. Westward gray slates, with intercalated grits, obtain on the line of the strike of the black Skiddaw slates, leading to the inference that coarser beds supply the place of the finer black slates on the eastern margin of the area.

The Rev. W. S. SYMONDS read a paper *on a Fossil of the Severn Drift*. The excavation of the alluvial drift of the Severn at Tewksbury Horn is nearly forty feet deep, and the river-bed itself has been dredged to the depth of seven feet. The river-bed contains relics of the human race several feet below the present gravel. These are associated with the remains of Roman pottery, the vertebræ of a whale, and many irregular round-shaped glass bottles of great thickness. The alluvial drift is a mass of clay and brick earth, 39 feet thick, resting upon an ancient river-bed of gravel and shingle. About 37½ feet from the surface we find the fossilized antler of a large stag (Cervus), which the author imagines may have been of the Irish elk. This antler is at the base of the brick earth a few feet above the gravel. It is interesting to observe the difference in the state of fossilization between the vertebræ of the whale, which is little altered, and the antler of the deer, which has been nearly entirely converted into stone. The antler is in much the same state as the mammalian remains found by Mr Strickland in the drifts of the Avon Valley; while the vertebræ of the whale may be compared with the large crooked-horned head of a bison obtained by Mr Strickland sen. from the Avon river-bed. From comparison of the fossils, the author is inclined to believe that the cervus antler of the Severn is the relic of an animal that lived in the period of the *Bos primigenius* (a fine skull of which is in Mr Strickland's possession); whether it belonged to the *Magaceros Hibernicus* or not remains to be proved.

ARTHUR B. WYNNE, Esq., read a paper *on the Tertiary Clay and Lignite of Ballymacadam, in the County of Tipperary*. In this paper the author called attention to an extremely interesting and very isolated deposit of white clay and lignite, supposed to be of tertiary age, found about a mile to the east of Caher, in the county of Tipperary. He stated that the clay occurred in a small hollow in the carboniferous limestone, though not at the lowest point. It was not discoloured by burning, and was capable of being manufactured into pipes and many articles of finer ware. A singular circumstance is the occurrence at this place of some of those natural drains so common in the carboniferous limestone of Ireland, called by the peasantry "swallow-holes." The place where the clay was found had a strong odour of sulphuretted hydrogen gas. It is, he observed on the authority of Dr Griffith, similar to the large and distant deposits of Tyrone, Armagh, and Roscommon, in Ireland, and Devonshire in England.

SECTION D.—ZOOLOGY AND BOTANY, INCLUDING PHYSIOLOGY.

Dr DAUBENY read a *Final Report on the Vitality of Seeds*. He stated that about sixteen years since Mr Strickland and others and himself suggested the advisability of instituting experiments for the purpose of ascertaining, by way of experiment, as far as possible, the terms to which different seeds would retain their vitality. They were all well aware of the statements as to the germination of mummy seeds, and it was with the view of determining the various questions which arose that a committee was formed in 1840 to make experiments, which were made in the following manner:—A considerable number of seeds of as many kinds as could be procured were placed in porous stone jars, covered so as to exclude insects and rapid circulation of air, and so as to secure a slow circulation. The experiment had been carried on for seventeen years, and each year a report was given, stating the number of seeds which had germinated, which were resown until their vitality ceased. As the seeds which had originally been procured had, with the exception of four, lost vitality, the inquiries were considered to have come to a close, and the final report was brought forward. He submitted a paper to the meeting containing a general summary of the experiments from 1841 to 1857, and a tabular statement, showing the relative vitality of different kinds of seeds, from which it would be seen that the greater number of seeds lost their vitality at eight years, and that forty-three years was the longest period to which they retained it. The experiments made by the Association did not confirm the common belief regarding the indefinite vitality of certain seeds, for instance, the mummy seed. If any naturalist would suggest a better mode of preserving the plants, it would be well to institute a new set of experiments; but as far as was at present known, the plan that was adopted was the most likely to preserve their vitality.

Dr Lankester observed that the Report was very valuable, but that the result was not in accordance with what vegetable physiologists would expect. The question, however, was, whether the Report settled the mooted point of the duration of vitality in seeds. As to the mummy seeds, too much care could not be taken in relating such cases. It was not sufficient to get a parcel of seeds from a mummy and put them in the ground; the mummy should be got out of the tomb, because no one could say what might not occur during the transfer of the mummy-case; so that unless some person quite capable of making the experiment should unrol the mummy with his own hands, plant the seeds, and keep them constantly under his own supervision, the experiment should not be considered satisfactory.

Dr Steele, in confirmation of Dr Daubeny's observation, said, that in the course of last year Mr John Ball sent through his brother to him (Dr Steele) a packet of wheat which had been taken out of a mummy-case. He sent the wheat, which was in a vase in the case, to Mr Moore, the curator of the Royal Dublin Society's Gardens at Glasnevin, who had tried them with all the knowledge and skill which he possessed, but not one of them vegetated.

Dr Daubeny observed that he should have mentioned that they had tried seeds taken from mummies, and in no instance did they vegetate.

Mr Moore stated that he had tried those seeds mentioned by Dr Steele with the greatest care in the garden stove-house and in the open ground. He also experimented on them by placing them in boiling water, by which means he had raised very old seed, but he failed altogether in raising them. He had no doubt but that many persons present were aware that seeds could be raised of a greater age than that stated in Dr Daubeny's report, and he had no doubt but that he would be able to raise plants for forty years hence.

In reply to a question from Dr Lankester,

Dr Steele said that the seeds were sealed in his presence by Mr Thomas Ball. He (Dr Steele) transmitted them to Mr Moore. They were from the mummy of Thebes, he thought, and had a fragment of the pottery of the vaults attached.

Mr Moore related a circumstance, that during the storm of 1839, a tree, 100 years old, was blown down, and in the centre of the trunk was found a quantity of seeds, which were set, and having vegetated, turned out to be the common laburnum.

The Rev. Mr Higgins stated that seeds which had been given to him as having been taken from a mummy did germinate, but he should confess that the circumstances under which he received them did not give him confidence. They were given to him with the intimation that they were found wrapped up in a mummy-cloth, with a quantity of bitumen about it. He asked if any experiments had been made of seeds inclosed in hermetically sealed cases?

Dr Daubeny replied that it had been tried, and that the conclusion had not been favourable.

Professor Archer observed that it was believed that some seeds, melons for instance, were better for being kept for a long time, and that gardeners actually kept melon seeds in their pockets for a considerable time to improve them.

Mr Moore said that such was the case, although he could not account for it. He mentioned that a friend in India, being unable to procure some of the beautiful plant berberis which he promised him, sent him a pot of jam made of it by the natives, and that he sowed the jam, and not one seed missed, and a new and beautiful plant was by that means introduced into the country.

Mr Ogilby remarked that the great question was, how were the seeds to be preserved before the experiment was made?

Mr Nevin, in reference to the vitality of melons, stated that he once raised a crop of that fruit, and from the seeds a second set of seeds was sown, from which there was an abundant crop, if not a more abundant one, than from the seeds which produced the first crop.

The President remarked that it was with the idea of ripening them that melon seeds were retained in the pocket for a time, and it was probable that they became more fruitful after having been kept over for some time, for the same reason that plants were more likely to come to full flower after a lengthened season of rest.

Mr Emerson referred to the fact, that if a forest of pine trees was cut down in New England, a forest of oak trees was sure to spring up in its place. He was inclined to think that acorns were carried great distances by several species of squirrels, who, having eaten all except the germinating part, in some manner left it after them; and then, when the old pine forest was cut down, and the influence of the sun let in, the seeds of the oak thus deposited germinated. In reference to the influence of heat on seeds, he said that wherever the process of burning down the branches of trees took place, a small species of wild cherry was sure to spring up in the vicinity in great numbers, though forty miles from any cherry tree; but if the ground was not burned over, and if the stumps were allowed to rot and be broken up by the plough, the same number of plants would spring up, but of a different species.

Professor GEORGE WILSON read a paper *on the Employment of the Living Electric Fishes as Medical Shock Machines*, of which the following is an abstract:—The author, in prosecuting inquiries into the early history of electrical machines, did not originally contemplate going farther back than the seventeenth century, or commencing with any earlier instrument than that of Otto Guerick. His attention had been turned to the living torpedo as a remedial agent, and he now felt satisfied that living electrical fish were the most familiar and earliest electrical instruments employed by mankind. He adduced the testimony of Galen and others in proof of the practice, and as proving that "shocks" had been used as a remedy in paralytic and neuralgic affections before the Christian era. Still higher antiquity had been claimed for the electric Silurus, on the supposition that its Arabic name, "Raad," signified "Thunder Fish," and implied the nature of the shock; but the best Arabic scholars had shown that this was not the case. In proof of the generality of the practice of employing zoo-electrical machines, he alluded to the remedial application of the torpedo by the Abyssinians—of the gymnotus by the South American Indians, and the recently discovered electrical fish by the dwellers on the Old Calabar River, which falls into the Bight of Benin. The native women, he said, had a habit of keeping one or more of those fishes in water, and of bathing their children therein, with the view of strengthening them by the shocks which they received, which were very powerful. Having observed on the proofs of the antiquity as well as generality of the practice under notice, he concluded by directing the attention of naturalists to the probability of additional kinds of electrical fishes being discovered, and to the importance of obtaining the views of the natives familiar with them in reference to the sources of their power, and to their therapeutic employment.

Mr Hyndman then read *a Provisional Report of the Belfast Dredging Committee*, including a list of Foraminifera, by Professor Williamson; and of shells found in shell sand, by Mr Waller and Mr Hyndman.

Mr Patterson read a Report by Professor Dickie, M.D., *on the Mollusca of Strangford Lough and part of the Irish Channel.* The Report stated that one hundred species were dragged, viz., 57 bivalves and 43 univalves. The locality which yielded the greatest number was near the junction of the narrow channel (half a mile broad by three in length) with the wider part of the lough, the proportion being—bivalves, living, 29; dead, 17—46 species: univalves, living, 22; dead, 29—51 species. Two miles farther up, and five or six from the open sea, the numbers dragged were—bivalves, living, 10; dead, 22: univalves, living, 10; dead, 8—18 species, being about half the number in the former locality. In the wide part of the lough, still farther from the sea, the numbers were—bivalves, living, 21; dead, 5: univalves, living, 8; dead, 5. In the open sea, opposite the entrance of the lough, the drag afforded proof of very regular distribution to the distance of seven miles from the bar. The report then went on to state that in taking a general review of the molluscan fauna of Strangford Lough, and of part of the Irish Channel immediately opposite, the absence of the Lusitanean and South British types was remarked, and the general occurrence of those of the European types, with a large proportion of those called Celtic, and some of those considered as more peculiarly British were also plentiful. Those of the Atlantic type were generally rare, the Arctic type being just very partially represented. The general conclusions arrived at were, that the mollusca secured here belonged mainly to the European and the Celtic types, with a moderate proportion belonging to the Atlantic, and a very few Arctic forms.

The Rev. F. O. Morriss then read a paper *on the Specific Distinctions of Uria troile and Uria lachrymans.* He showed that in the *Uria lachrymans* the eye is larger than in the *Uria troile*, and this in addition to the permanent white streak from which the bird derives its name in the Latin, French, and English languages; and the darker colour of old birds he considered to establish the species as distinct. He pointed out the *Corrus coronæ* as only distinguishable from *Corrus cornix* in a portion of the plumage; and though the birds were different in habits, so were the young and the old birds of one and the same species, *Arus marinus*, the former being gregarious and the other not. On the whole, he concluded that neither in the shape nor size of the bill or feet was there any but accidental or temporary difference between individuals of the two species, as imagined by Macgillivray and others; but the distinctions he had pointed out, existing as they did *semper ubique et in omnibus*, were permanent specific characteristics, and marked the individuality of the species.

Professor **Kinahan** read a paper, and exhibited *a new species of Galathea*, for which he proposed the name *Galathea Andrewsii*. The species is remarkable for its elongated slender fore legs, which in their character approach the genus Munida. The species is exceedingly common in Dublin Bay, where it is frequently captured by the dredges.

Mr **Patterson** read a note of the quantity of Litorina, littoral periwinkles, shipped at Belfast during the years 1853, 1854, 1855, and 1856, which had been furnished to him by Edward Getty, Esq., secretary to the Harbour Commissioners of that port. In 1853 there were exported 1034 bags, containing 181 tons, or 3102 bushels; in 1854, 2626 bags, or 459½ tons, or 7878 bushels; in 1855, 2286 bags, or 400 tons, or 6855 bushels; in 1856, 786 bags, or 137 tons, or 2358 bushels. Such of these as are not yet in the Bay of Belfast are principally collected on the coasts of the county of Down, but the banks from which they have been derived are becoming exhausted, and are no longer capable of supplying the demand. The quantity of periwinkles deficient is now imported from Stranraer to Belfast, and thence reshipped for London. The local term in the north of Ireland for the periwinkle is "whelk." The whelk (*Buccinum undatum*) is known as the "buckie." Mr Patterson stated that they were shipped to London, and that they were got on the banks in Belfast Lough, and on the coast of the County Down.

Dr Wyville Thompson stated that he had been informed that from the islands of Scotland great numbers of periwinkles were also shipped for London.

Dr Lankester said it would be of great importance that this section of the Association should take up the subject, and draw up some rules for the preservation and propagation of animal life.

Mr Patterson said that the Commissioners of Fisheries were anxious to get information on this important subject, which they found one of great difficulty to deal with. If they had any competent authority on the habits of fish and the mode of their development, they would be able to determine the times at which they should be taken. If the government would therefore employ an eminent zoologist to collect and arrange information on the subject it would be the way to promote the object, and the association should therefore direct their attention to it. The Board of Trade were, he believed, at present engaged in investigating the oyster banks, on which there was some dispute, with the view of determining the close and open seasons.

Professor Wyville Thompson said that there were certain circumstances and seasons in which the ova of animals were not developed; and with regard to marine animals, this fact was not so well ascertained as it was in reference to others. It was well known that in certain seasons butterflies disappeared from some localities, and that the seasons had a great effect on the production of all kinds of animals. The variations in them should therefore be attended to, and their effects guarded against by greater attention being devoted to the artificial propagation of fish.

The President stated that one of the commissioners of fisheries had expressed to him his great anxiety that zoological information should be collected which might serve as an authoritative guide on the subject.

Mr J. R. Green read a paper *on British Naked-eyed Medusæ, with notices of six Undescribed Forms.* He glanced at the progress which had been made in this department since the publication of Professor E. Forbes's monograph. He also read a list of all the Acalephæ hitherto observed by him in Dublin Bay, in all amounting to 24 species. He then entered into a description of his six new naked-eyed forms, with observations on the study of their development, and concluded by calling the attention of the members to the study of this interesting group of animals.

Mr Patterson made some observations on the subject, and stated that a work, part of which he held in his hand, was nearly ready for publication, by the late lamented Dr Edward Forbes, entitled, "The Natural History of the European Seas," from which valuable information would be obtained.

Mr George Hyndman made some observations *on a Remarkable Specimen of Fusus despectus*, which he exhibited.

Mr Ogilby read a paper *on the Dispersion of the Particular Breeds of Domestic Animals as connected with the great Ethnological Divisions of Mankind.*

Mr D. Moore, Curator of the Royal Dublin Society's Garden, Glasnevin, read a paper entitled *Observations on Plants which, by their Growth and Decomposition, form the Turf in Ireland.* He observed that, although much has been written and reported on the bogs of Ireland, singularly enough no person had yet given any intelligible account of the plants which form them. He divided the varieties of bog into red bog, brown, black, and mountain bog, carefully stating the plants which formed each. He considers the red bog to have been formed on the sites of ancient lochs or deep morasses, of which upwards of one million of acres exist in Ireland, more than two-thirds of which are situated west of the River Shannon, according to the reports of the commissioners. The black bog he considered to have been formed on the sites of ancient forests, as was evident from the number of roots and stems he has found therein. He did not consider the idea correct, of species having once flourished on those bogs which have since died out and been replaced by others. His opinion was, that the Irish bogs were of too recent a date, and that we had all the plants existing yet in Ireland which have formed them, with the exception, probably, of Lough Neagh, which may have been anterior to the glacial epoch of geologists; but he thought it must be exceedingly hazardous to state what the species were which formed the fossilized wood found there. Mr Moore, in allusion to this portion of his paper, stated that there still exist a few trees of the ancient Scotch fir on the Earl of Arran's property in the County Mayo, which once formed such extensive forests in Ireland.

Mr N. Niven, Garden Farm, Drumcondra, then read a paper *on the Remarkable Results of Experiments on a Fruit-bearing Tree.* This paper went to show what, from an idea gathered from the last chapter of the Revelation of St John, the experimenter was led to anticipate, that he might succeed in so far realizing a certain portion of the remarkable description of the wonderful tree therein alluded to. His subject for the experiment was the pear, on which he commenced his operations in 1855, and at the present time (1857) has nearly realized the remarkable result of a succession of fruit from the one tree for each month in the year. The tree in question has been grafted with forty varieties of the finest pears, and is in great vigour of bearing.

Dr Redfern read a *Notice of a Simple Method of Applying the Compound Microscope to the Examination of the Contents of Aquavivaria.* He stated that he had for some time made use of a very simple and convenient arrangement for examining objects in aquaria with magnifying powers up to those given in the half circle objective. It consisted of a vertical stem of one-inch brass tubing, about two feet long, supported by a heavy cast-metal foot. In this stem a three-inch piece of tube slides, and is supported at any height by a ring and pinching screw below it. This short sliding tube has another like piece attached to it, and rotating on an axis at right angles to the vertical stem. Through this second piece a tube, two feet long, slides horizontally, its best working position being such that three-fourths of its length projects on one side of the vertical stem, and the other fourth on the opposite. To the shorter end of this horizontal tube a stem, carrying the tube of the body of the microscope, is attached by a ball-and-socket joint, admitting of a coarse adjustment by a sliding tube, and of a fine adjustment by acting on the long arm of the lever formed by the transversely sliding tube to the end of which it is attached. By this means the compound microscope is capable of being applied to any part of the surface of the side of an aquarium measuring two feet, or to the surface of the fluid which it contains. The whole arrangement can be made by a gas-fitter for the sum of about 25s., with sufficient accuracy for the uses for which it was designed. Abundant illumination may be obtained in cylindriform vessels by a small flat mirror let down into the aquarium, and moved into any position by wires, which can be attached to it in a very simple manner.

Mr J. S. Bowerbank read a *Further Report on the Vitality of the Spongiadæ.* The author referred more especially to the vital powers of the dermal membrane, and to the imbibing pores of *Spongilla fluviatilis.* These organs have the power of opening and closing at the pleasure of the animal, in a similar manner to the oscula described in the previous report on the same subject, but, unlike those organs, which are situated on elevated bladder-formed portions of the dermal membrane, and which are constant in their action and continuous in structure, the pores, when once closed, rarely open again in precisely the same situation. The essayist concluded by stating that the structure and habits of the fresh-water sponges were strictly in accordance with those of the marine Spongiadæ.

Professor Kinahan read *Notes on Certain British Genera of Isopoda.* He gave a lengthened description of the structure and habits of the Isopoda.

Mr E. Percival Wright, director of the College Museum, gave an account of *a Visit to Mitchelstown Cave, in the county of Tipperary,* in the early part of the present month, by Mr Halliday and himself, on their return from a short entomological tour in the south and south-east of Ireland. It was pretty generally known, he believed, to all present, that various living animals had been discovered inhabiting the deep recesses of caves. About a century ago the *Proteus anguinus* was found in the caves of Carniola, and since that time various insects and crustaceans, and even fishes, have been discovered, both in Europe and America. Those animals were found very far in the interior of the caves. In those of Carniola none were found within two miles of the mouth, and hence they never see light; and as, under these circumstances, eyes would be quite useless to them, they are not provided with any, so that they are quite blind, and never stray into the upper world. This is a deeply interesting fact in relation to the theory of single centres of creation, for here is a species with its centre of creation and the extent of its wanderings all within the limits of one small district—resembling those plants and animals which inhabit some of the small islands in the Pacific and other oceans, and are found nowhere in the world besides. The caves of Carniola were visited by Schiodte in 1851, and he subsequently published a very interesting account of his researches. Mr Murray had visited some of the large natural caves in Derbyshire, but no blind animals had been found in England. Mr Wright went on to say that Mr Halliday and he, after an hour's drive from Cahir, arrived at the foot of the small mountain within which the caves are found, the geological aspect of which and the surrounding country he briefly described. The townland of Coolnagarranroe lies in the valley which separates the Galtees and Knockmildown chains of mountains—the former constituting its northern, and the latter its southern boundary. The prevailing rock at this extremity of the Galtees is conglomerate, which occasionally passes into sandstone; while that which composes the opposite chain of hills is an intermediate between sandstone and schist. The material of the decomposed valley is compact gray limestone, and this rock, in the townland already mentioned, forms the small rounded hills, within both of which cavities of considerable magnitude exist. One has been known from the remotest antiquity; the other was discovered about twenty four years ago by a man engaged in quarrying. Having penetrated the cave by a narrow passage about four feet in width and thirty-three in length, and which gradually declined until it terminated in a vertical precipice many feet deep, down which they descended by means of a ladder, they proceeded onwards until they reached the lower middle cave. This is upwards of thirty-five feet high; the roof is covered with small stalactites, and the floor is strewn with large tetrahedral blocks of limestone. About the entrance of the cave some specimens of a macrotoma (*Podua Linnæus*) were running over the rocks. They appeared to be bewildered by the light as it approached, and stood still, so that by putting a quilt over the spot one or two of them were caught; but unless this was done dexterously, they leaped away. Advancing farther, at one time down precipices dangerous enough to make one distrust the guides, then creeping for many yards along the ground, which was covered with a fine red clay, so fine as to resemble red paint, and then along places where they could neither walk nor creep, but were obliged to crawl flat upon the ground and wriggle through,—at the farthest end of the long cave they discovered a species of the same group as that which they had previously noticed, but one about which there could be no mistake, as it was decidedly a native indigenous to the caves. This was a Lipuva somewhat larger than the *Lipura fimetaria*, which abounded on the surface of some little pools formed by drippings from the roof. They clustered especially on floating lumps of soft calcareous concretions, and also in the moist rocks of the sides of the caves, especially about some dusky stains of the incrusted rocks. The surface of these rocks was scraped; but after being dried the matter appeared to consist chiefly of fine earth, with a smaller proportion of vegetable granular matter, apparently the first state of some algoid growth, presenting no trace of regular organization. They were inclined to identify this Lipuva with the species which Schiodte found in the Adelsberg grottos, although there are some points in which his description does not exactly correspond. The true specific distinctions, however, of this long-neglected group of insects are scarcely so well understood as yet as to induce them to propose a new specific name for it on the ground of the differences which they noticed. They brought home a good number of specimens from the Mitchelstown caverns in excellent preservation, and some were yet alive; but unfortunately they found it impossible to pay any attention to them for a fortnight, and by that time their bodies were completely dissolved away. A few specimens were preserved in alcohol, and alone furnished the materials for examination; and those who knew the fragile and watery consistence of insects of this group must be aware that some of the characters of external form, and all those of internal organization, were liable to be somewhat affected by their being kept. Only one of the specimens appeared to be quite mature, owing, probably, to defective manipulation in the microscopical examination. There seemed to be a very important difference between their and Schiodte's species, for, on opening the head and taking out the contents, they could not discover the least trace of eyes, whereas he detected fourteen ocelli on each side quite white, from which he inferred that they were useless for vision. Near the Garret Cave, while engaged in turning over some stones, he found the skeletons of several bats, most probably not of very ancient date, as this portion of the cavern was the nearest to the surface, and it was quite possible there may be some slight communication with the open air. He expressed a hope that these caves, as well as those of Dunmore, would be examined with greater care than had been hitherto bestowed upon them. Even in the Mitchelstown caves many places are still unexplored; and perhaps if the river were throughout its length carefully dredged with a water net, crustacea might be found. He attempted to wade it, but its icy coldness, and rapid deepening of its stalagmitic strand, prevented him from going in far. Mr Wright stated, in conclusion, that the paper which he had read could not have been presented to the section without the assistance of Mr Halliday.

The Rev. Mr Higgins suggested the possibility that the blind beetles noticed in the paper might belong to a species that had lost their organs of sight so as to fit them for the circumstances and place in which they were discovered.

Mr Halliday observed that the insects found in the cavern had other peculiarities besides their want of the organs of sight, which showed them to be a distinct species. There could be no doubt that they had been formed without eyes, which fitted them for the places which they inhabited.

Mr Halliday then exhibited a beautiful specimen, inclosed in a bottle, of the migratory locust, which had been found in the College grounds some minutes previously. He observed that it very rarely visited this country, as it seldom came so far north, but inhabited Western Europe and the basin of the Mediterranean.

Dr KINAHAN read a paper *on the Honey Lobster*; and

Professor MACDONALD offered a few remarks upon some crustaceous species.

Professor KINAHAN read a paper, communicated by Dr Buist, *on the Lotus or Sacred Bean of India.*

Mr R. SCHLAGINTWEIT read a paper containing remarks *on some Animals of Thibet and India.*

Mr WILLIAM ANDREWS read a paper containing some remarks *on the Sea Fisheries of Ireland*, with reference to their investigation practically and scientifically. Having stated that the object of the paper was to create an investigation into the Irish fisheries, with a view to their greater development, he alluded to the importance of those fisheries, especially the west and south-west coast. He said the British fisheries in Newfoundland did not receive the attention to which they were entitled, and that on our own coast the cod fishery had much declined—that fish seldom being seen in our markets except in winter or spring. He then referred to the practice of sounding as a mode of discovering, by means of the marine animals caught in the process, the particular localities which particular fish frequented and their habits. He said that the ling season was the most important in connection with our fisheries, but that in consequence of the smallness of the boats it was carried on only during the spawning season. He then referred to the practice of trawling, which he said was most useful and profitable, and to the objections of the fishermen to adopt it. He said that he attended in June 1852, at the investigation in Galway into the fishery on the west coast. The Rev. Peter Daly presided at that inquiry, and everything was carried on with the greatest impartiality. A number of Claddagh fishermen were there examined, who showed that they knew nothing of the spawning of fish, and that they merely fished as their forefathers did before them. Mr Andrews exhibited a specimen, which he said it was insisted by the fishermen was spawn which the trawlers took up, but which he discovered was sponge, and not spawn. He then alluded to the erroneous views that were formed of the migratory habits of fish, and in conclusion he said that science should come to the aid of practical knowledge so as to develop the fisheries of the country, and while such eminent scientific men were in existence as those which were attached to this section, there should be every hope that some scheme would be shortly devised with that object.

Professor Allman said that this very valuable paper proved the importance of bringing scientific knowledge to bear on the every-day pursuits of life. By his discovery in reference to the sponge which was supposed to be spawn of fish, Mr Andrews had dissipated a phantom that was exercising a most injurious effect on the development of the fisheries of the country.

Dr Daubeny read a paper by T. Maxwell Masters, *on Contributions to Vegetable Teratology*, in which an account was given of various vegetable monstrosities.

Dr Steele instanced the case of *Mejacapœa Polyandria*, that flowered in the Glasnevin Gardens, which was, perhaps, the only instance in the whole order of the crucifera in which so many as twelve stamens were developed.

Mr Percival Wright instanced a case of monstrosity in a fuchsia.

Dr Steele read a paper by Professor Brickman *on the Occurrence of Cuicus tuberosus.*

Mr E. Birchell communicated a list of additions to Irish Lepidoptera.

M. M. Neven read a paper on the importance of a thorough understanding of the root principle in the cultivation of trees.

Sub-Section D.—PHYSIOLOGICAL SCIENCE.

Professor Laycock read an abstract of a paper, by Professor Alison of Edinburgh, *on Certain à priori Principles of Biology.* This paper went to show that there are certain principles which must be admitted, although inconceivable to our minds, and that these principles present the same basis for physiological science as the axiom of geometry for geometrical science, or as certain intuitive principles for the science of morals. It may be said that the paper was an attempt to apply the doctrines of the Scottish School of Metaphysics to physiological science. On account of the recent illness of the distinguished author of this paper, Professor Laycock was unable to do more than communicate an outline of his views.

Dr Gairdner, of Edinburgh, as a pupil of Dr Alison's, explained the nature and tendency of his distinguished master's views, which were chiefly directed to oppose the modern tendency of medical investigators to degrade their science to that of a subordinate department of chemistry on the one hand, or of mechanical science on the other, omitting all considerations of that higher, though less intelligible class of phenomena which are known as vital.

Dr **Haughton** read his paper *on the oriental Bath.* This bath, he observed, was of very great antiquity, for we read of its existence amongst the ancient Egyptians, Chaldeans, and Persians. A notion prevailed that the Eastern bath was not to be used except in particular climates, but it would be found that the ancient Greeks and Romans were acquainted with it, and were in the habit of using it frequently. It was introduced by the Romans into Spain, and was afterwards brought into France and the British islands. He felt confident that if proper search were made sufficient evidence would be found of its having been extensively used in these countries. Having expressed his surprise at the disuse into which the ancient bath had fallen among civilized nations, he proceeded to give a description of the mode in which it was used, and to offer some observations upon the physiology of the process. He regarded the eastern bath as a pleasure free from vice, and a luxury which was not injurious. It only required sufficient demand in this country to become so cheap as to be accessible to all classes. The price of a bath in ancient Rome was about one-eighth of a penny of our money. There was no drug to be compared to it in a sanitary point of view as a purifier of the system. Gout, rheumatism, and chronic and skin diseases were not known among the Turks, who were seldom ill. The physicians believe that those effects were owing to the great attention which they bestow upon the functions of the skin, which the most eminent physiologists now consider to be analogous to the functions of the lungs. Deformed people were also rarely to be met with amongst the Turks. He was of opinion that something more than bathing was required to produce a fine race of men, and the people of Europe should follow the practice of their ancestors and adopt the ancient bath. Our own country, he observed, had led the way in this movement; for the only building of the kind in the west of Europe was opened recently near Cork, and was used as a remedial agent with great success.

Dr Laycock observed that in Liverpool there is a plunge bath where boys can gambol about every day for a very small sum, and without actually adopting the Turkish bath in all its details, he thought they might erect baths suitable to the wants and circumstances of this country.

Mr Wrenfordsley stated that similar baths to that alluded to at Liverpool, had been established in Paris and Bordeaux.

M. l'Abbe **Moigno** communicated in French, on the part of M. Le Baron **Heurteloup**, *a New Method of Administering Chloroform.*

Dr **Poznanski** read a paper *on the Relations of Atmospheric Vicissitude with Epidemic Diseases*, and exhibited a very ingenious instrument for estimating the rate and force of the arterial pulse.

Dr **Hayden** made a communication *on the Physiological Relations of Albumen.*

Dr W. T. **Gairdner** read a paper *on the Mortality of Certain Diseases.* The object of this paper was to show the prevalence of certain causes of death among the population of a great city, as shown by the analysis of somewhat less than 300 cases of death in the population of Edinburgh. The author commented on the most frequent causes of mortality, and showed the sources of fallacy attaching to the returns of causes of death hitherto made. He made a suggestion with regard to the observation of causes of death in hospitals, but said that the registration of deaths on the large scale is a work of difficulty and labour so great, that any interference with the present system was not within the scope of the paper.

Drs Laycock and Lankester made observations at considerable length on the very valuable communication of Dr Gairdner.

Dr Carte communicated some observations in reference to *the Relation of the Nervous System to the Functions of the Skin.*

Professor Hayden read a paper *on the Physiological Relations of Albumen in the Body.* His views were supported by a number of experiments which he performed on the lower animals, and illustrated by microscopic demonstration of the action of urea on the elements of the blood.

Dr Lankester read a paper *on Alternation of Generations, and Parthenogensis* in plants and animals, pointing to the numbers of instances in which reproduction takes place, both in plants and animals, by means of asexual and sexual individuals.

Mr Lister brought before the section the result of some observations which he had made in the year 1853 *on the Flow of Chyle* through the lacteals and mysentery of the mouse.

Dr Lyons made a communication, on the part of Dr Hardy of Dublin, with respect to *an Apparatus for the Production of Local Anæsthesia,* by which it appeared that an instrument for this purpose was invented by Dr Hardy in 1853; and subsequently a more complete and perfect apparatus, by which the vapour of hot water can be combined with that of chloroform, thereby making the vapour of the anæsthetic agent more effective for the alleviation of pain.

Dr Robert M'Donnell read a paper *on the Valvular Apparatus connected with the vascular system of certain abdominal viscera.*

Professor Carlisle, in some observations *on the Junctions of the External Ear*, described in detail the exquisite arrangements by which vibrations of sounding bodies are received and transmitted by the external ear.

Dr W. T. Gairdner read a paper *an the Action of the Auriculo-ventricular valves of the Heart.*

Dr M'Clintock brought forward a series of observation made by him in his official capacity in a maternity hospital, as to *the Average Weight of the Heart in Children* who survived birth seven days, two hours, and others still-born.

Mr John Pope Henessy read a paper *on some Changes in Blood-corpuscles.* He stated the results of some of his microscopical observations.

Professor Lyons read a paper *on the importance of introducing a new and uniform standard of Micrometric Measurement.*

American Association for the Advancement of Science. Eleventh Meeting. Montreal, August 12–19, 1857.*

MATHEMATICS AND PHYSICS.

Captain Wilkes *on the Zodiacal Light.* Observations made by the Exploring Expedition under his command, proved that the light has not changed its character since its discovery, more than two centuries ago. He mentioned various theories regarding its origin; that it is derived from the atmosphere of the sun; that it is a nebulous ring, with the sun as a centre; a nebulous ring with the earth as a centre; a nebulous matter floating in space, from which the showers of stars may be traced, when the matter comes in contact with the earth; but he thought it is impossible to reconcile these theories with the facts. He described the various phenomena of the light, different from the extended light of sunset and of twilight. It varies with the position of the observer, the morning light does not correspond with that of evening, but the inclination to the ecliptic of the former, is tranverse to that of the latter. The light is the result, in his opinion, of the light of the sun falling perpendicular to the earth's atmosphere, in the plane of the ecliptic. He compared it to the effect produced by letting the rays of the sun enter a hole in the shutter of a room which would be otherwise dark, making visible that portion of the atmosphere which is illumined by the rays.

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* This abstract has been prepared chiefly from notices of the proceedings given in the Boston Daily Advertiser and the New York Tribune.

Professor E. S. Snell *upon the Vibrations of the Fall over the Dam across the Connecticut River, at Holyoke, Mass.* At the time of observation there was a sheet of water two feet deep, 1017 feet in width, and 30 feet high. By going behind the sheet, it is at once seen that the currents of air rush in and out alternately, with a vibrating motion. The fall of the water causes a rarefaction of the air behind, which in turn produces the pulsatory motion of the sheet. The vibrations vary with changes in the atmosphere or in the depth of the water over the dam. At one observation he had counted 137 vibrations, and at another 256 vibrations in one minute. The vibrations are communicated to the land and buildings in the neighbourhood. A count of the vibrations of a window-sash, gave the same result as a count at the base of the fall.

Professor Bache *on the Measurement of a Base Line on Epping Plains, Washington County, Maine*, for the primary triangulation of the Eastern section of the coast of the United States. The selection of this interior site (between Bangor and Calais) was rendered necessary by the absence of any long beach upon the coast of Maine. He described the physical character of the plain, and of the whole line, which is five and four-tenths miles in length. The measurement was taken with great care, and was a work of considerable labour, requiring the uninterrupted attention of all the operators, and continuing for eight days. The mean level of the line is 257 feet above tide-water, and the fact of its height, coupled with the novelty of establishing a line so far inland, constituted the chief interest of the paper.

Rev. Thomas Hill laid upon the table *a Chart of the Annular Eclipse of March* 14, 1858, showing that its beginning will be visible only East of longitude 69° west from Greenwich, and its close visible only east of a line joining the western end of Lake Superior and the city of Mobile.

Mr Hill then read a note upon *a new form of Arithmetical Complements* which he had been led to use in constructing *a Calculating Machine*. He is enabled to subtract and divide by the same movements as those by which he adds and multiplies.

The same gentleman, having at the Cambridge meeting, presented a paper upon "Peirce's circular co-ordinates," now added some remarks upon other possible systems of co-ordinates in one plane. He obtains twenty-two couples of quantities defining infinitesimal curves, either member of each of which may be considered as the independent variable, and the other as its function; thus obtaining, in one sense, forty-three general systems of co-ordinates by which a curve may be represented without the use of anything more than ordinary algebra. He regarded about one-fourth of his systems as worthy of investigation.

Rev. George Jones, U.S.N., read *an Account of One Hundred and Twenty-three Observations on the Zodiacal Light, made at Quito, Ecuador.* Quito itself is 9800 feet above the sea, and the observations were made from a hill 10,000 feet above the sea. Some interesting facts are given to show the great brilliancy of the atmosphere; Humboldt was able to see his companion at a distance of seventeen and one-third miles. The various appearances of the light were described, and the following deductions were drawn:—(1.) That the substance giving the light forms a complete circle across the sky; (2) This circle is a great circle in the heavens, with a width of 28°, and at a distance of 100,000 miles, and taking its central light as our guide, its descending node, at the time of observation, was in longitude 242°; (3.) It is a complete circle, distinct by itself, geocentric (or having the earth for its centre), and not very far distant from the earth. Mr Jones said that if the brilliancy of the Milky Way be represented by an ascending scale from 0 to 20, the zodiacal light will be represented by 6 or 7; that it is not observed by the people of Ecuador, nor was it seen by Humboldt when in that country.

Professor Peirce showed that by his investigations on Saturn's ring, the sun could not sustain a ring except between Mars and Jupiter; and even there, the great tides produced by those planets would break up the ring in small portions, forming, perhaps, the asteroids. To hold a permanent ring requires satellites or planets of a certain number and weight, such as Saturn has around him. In regard to our zodiacal light, it cannot be composed of small pieces, because it can readily be shown that they would pass in conflicting currents. But if gaseous, why does it not show the great tides which our large and heavy moon would produce? That it is really a ring is manifest, but there is a difficulty in reconciling the existence of a ring with the non-appearance of tides in it.

Professor Bache read a paper *upon the Winds of the Pacific Coast of the United States,* giving the results of observations made in connection with the Coast Survey at Astoria, San Francisco, and San Diego. There is a great preponderance of westerly winds at those places, while easterly winds preponderate on our eastern coast; there, however, the west winds are to east as 8 to 1; the west winds increase in summer and decrease in winter; the east winds occur in the winter, and hardly at all in the summer; the north-west wind prevails at Astoria and San Diego, while the south-west prevails at San Francisco; the summer months are windy, and those of winter calm; March and September, our most windy months, are the calmest there.

Professor Henry read *an Explanation of the Physical Conditions determinate of the Climate of the United States.* He first treated of the winds, and explained the preparations which have been made for observing and recording their direction; the results of these observations will greatly aid the philosopher in determining the laws and effects of the winds. The currents of water exercise an influence; the revolution of the earth causes the cold descending currents to take a westerly direction, while the warm ascending currents tend to the East. The topographical character of the country was also considered. The Appalachian range in the eastern portion has no effect upon the atmosphere; because the wind is dry when it ascends, and [illegible] in

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the cold, contracts again on its descent, and is restored to its original temperature. On the Rocky Mountains, however, the temperature is far warmer than in the same latitudes below, because the west wind, coming moist from the ocean, is condensed, and thus heat is evolved, so that the wind comes down upon the plains hot and dry. The great power of tornadoes comes from their course, which are onward and upward, not gyrating. He refuted the idea that north-easterly storms move from south-west to north-east, although it first begins to rain at the south. The storms themselves move from the north-east to south-west, acquiring, however, a general motion as a whole, towards the east. This may be represented by placing a rod upon the western part of the map of the United States, with a direction from N.N.E. to S.S.W.; then if we give this whole rod (along which the current and storm are supposed to flow), an easterly motion, such as it would acquire from the motion of the earth, it will be found that the lower part of the rod will reach the coast first; that is, the inhabitants of the south-eastern portion of the coast will be visited by the storm in advance of those north-east of them.

Dr WYNNE *on the Influence of the Gulf Stream upon the Atlantic Coast of the United States*, treating the subject in a hygienic light. He added that the peculiar conformation of the bottom of the sea has its effect upon the Gulf Stream, and therefore upon the climate.

Professor W. M. GILLESPIE, of Schenectady, N. Y., *on the Warped Surfaces occurring in Road Excavations and Embankments*. He shewed the precise nature of such a surface to be a hyperbolic paraboloid, and decided that the familiar "prismoidal formula" can be applied with perfect accuracy to the solid bounded on one face by a warped surface, the other faces being planes.

Professor JOHN LECONTE, of South Carolina College, gave an account of some preliminary researches *on the Alleged Influence of Solar Light on the Process of Combustion*. Most physicists have regarded as a fallacy the popular opinion that the action of the sun upon fire tends to retard the process of burning. Dr M'Keever, after a series of careful experiments, came to the conclusion that the rate of combustion in the dark exceeds the rate in the sunlight, by from 5 to 11 per cent; while moonlight has no such influence. Dr Leconte gave an account of some careful experiments made by himself, to test the same thing. The results convinced him that the rates of combustion in the sunlight and dark, other things being equal, are precisely the same.

In conducting his experiments Prof. Leconte endeavoured to secure two conditions, viz.:—

1. Absolute calmness in the atmosphere.
2. Exposure of the flame to the influence of intense solar light without heating the surrounding air.

The first condition was secured by performing all the experiments in a large lecture-room, with all the doors and windows closed. To secure the second condition, he employed a portion of the apparatus belonging to a large solar microscope, consisting of the reflecting mirror, the condensing lens and tube, together with the mechanical arrangements for adjusting the direction of the light. As the condensing lens was upwards of four inches in diameter, the intensity of the light could be increased nearly tenfold; so that its effects ought to be enormously exaggerated. This arrangement cut off all of the influence of exterior agitations of the atmosphere; while the concentrated pencil of light, thus thrown on the flame, traversed it, as well as the surrounding air, without imparting a sensible amount of heat to the latter.

In his experiments, Professor Leconte used the best wax-candles. These were found to burn with remarkable uniformity, provided the air was calm, and they be allowed to continue burning a sufficient length of time to form a well-defined cup for the melted wax, and to establish regularity in the process of combustion. The rate of burning was determined by securing a portion of the wax-candle to the bottom of one of the scale pans of a tail balance, and accurately noting the time it required to consume a given weight, say 60 or 100 grains. It will be observed that his arrangements enabled him to ascertain the rapidity of consumption of the candle alternately in the darkened room, and with a pencil of concentrated sunlight directed on the flame, without moving any portion of the apparatus, and therefore to test its influence under the same external conditions.

In the present stage of the investigation, Professor Leconte thinks that two deductions are warranted: 1. That solar light does not seem to exercise any sensible influence on the process of combustion. 2. That variation in the density of the air does exercise a very decided influence on the rapidity of the process: the rate of burning increasing with every increment of density, and *vice versa;* but the exact ratio between them remains to be determined.

Professor H. L. Smith, of Kenyon College, described *an Improvement in the Construction of Achromatic Telescopes*, which allows them to be furnished at from one-half to one-eighth of the former cost.

Professor Stephen Alexander, of Princeton, New Jersey, treated of *Some Special Relations of the Straight Line and the Various Orders of Curves.*

Dr J. H. Gibbon, of the Mint at Philadelphia, read a paper *upon the Diverse Weights employed in Modern Coinage, treating especially of Karat Grain Weights.*

Colonel G. C. Forshay of Texas, *on some of the Phenomena of the Texas "Norther" and Climatology.* The prevailing sea-breeze is from the south during the entire summer. It originates only a few miles from the coast, but extends far interior. It is a constant mitigation of the extreme summer heats, and never dies, except occasionally from 6 to 9 o'clock A.M. The trade-winds never reach Texas, as they originate at 20 to 23° north latitude; but the reflux furnishes from above all the rain-producing air of the Mississippi Valley. It flows back above the inward bound trades, sinks to the earth north of them, and laden with vapours from the Gulf of Mexico, travels north-eastwardly over Texas and the Mississippi Valley, and perhaps the Northern and North-eastern United States. A high stratum lies over it, whose course is rarely disturbed, and is always marked by the cirrus clouds. It comes from W.S.W. to S.W. This stratum having crossed the Cordilleras and discharged its vapours on the western slope, is perfectly dry, and from its height of about three miles must be colder than surface air by nearly 40°. From this stratum the western portion of Texas and all the rainless region of the plains, receive their supply, and hence the general barrenness in that quarter without irrigation. This air has no water to impart, and hence the American deserts.

The boundary between these two characters of climate every traveller recognizes at once, as it is marked by the growth of the cactus, as well as by the dryness of the air he breathes. It lies near a line drawn northwardly, tangent to the western fundus of the Gulf of Mexico, and San Antonio and Austin, lie very near it. Westwardly of this line cultivation of the great staples is not always practicable except by irrigation.

The Norther is a name given to a class of storms occasionally occurring in summer, but generally in winter or early spring. They usually commence in the morning, though they may not reach the observer's position till late in the day. The sky suddenly grows black in the north, the air is still and sultry, and in a few minutes a north wind strikes one. Generally there is a dash of rain, and afterwards a dry wind which sinks the thermometer very rapidly, in some instances 1° per minute for twenty minutes, but more generally 20° in an hour or two. It blows at the rate of 30 to 40 miles per hour, and lasts 24 to 30 hours. It is much deprecated by the inhabitants, who are compelled to provide winter clothing as much as for a latitude 10° further north. Its exceeding dryness exaggerates the cooling effect experienced, by evaporating all the moisture in the skin. Everything dries at once under its influence, books warp their backs, papers curl, furniture cracks, boards split, and the whole surface of the ground yields its dust to fill the air.

What can be the cause of this sudden and long-continued rush of air to the south? How are its sudden coldness and extreme dryness to be explained? Suppose the whole air of Texas, or the region of the Norther, covered by the stratum of air, derived from above, by the reflux of the Trades; this air, having a temperature of about 70° at the south, and with a high dew point and nearly at rest, would be overlaid by a stratum of air two or three miles above, some 30° or 40° colder, and almost perfectly dry. Contrary to the common impression, dry air is heavier than moist air, and consequently there must be a tendency of the superstratum to descend, and return to feed the Trades, no longer supplied from the warm and saturated margins. Suppose, then, a plunge or cataract of the higher, cold, dry air, to take place, and to discharge itself southwardly upon the earth and sea. After the jet first broke through the stratum and pushed its way beneath it, the current would enlarge on both sides, and assume, perhaps, the form of a wedge, widening and sweeping over a large space.

The current from the north lifting up the humid, warm air, the latter would have its vapour condensed, and a sudden shower of rain would be the consequence, and in some instances the fall through the cold stratum of air would freeze the rain drops into sleet or snow. This condensation always happens south of the original plunge. North of that point, rain and mist sometimes occur, but the Norther often sets in perfectly dry and clear. He further remarked that the Northers seemed to have a weekly periodicity,—of 12 which he noted last winter, 11 returned on Saturday or Sunday or both. It is always very warm just before the appearance of a Norther.

The periodicity of storms on the Atlantic coast, was also remarked by several gentlemen. Professor Henry accounted for it, by supposing that a given storm, required about a certain period of time to go through its various stages, and reform itself for repetition,—taking, of course, about the same amount of time in each case to go through its several stages.

Mr E. S. Ritchie, of Boston, *on an improved construction of Ruhmkorff's Induction Apparatus.* The improvements consist in making the strata of the wire in the secondary helix perpendicular, instead of parallel, with the axis; in making the insulation more perfect, and obviating in great measure the danger of a discharge of the spark from one stratum to another; in substituting for De la Rive's interruptor one which makes the breaks instantaneously and is entirely under the operator's control. In the apparatus exhibited by Mr Ritchie, the length of wire is 60,000 feet, and he has obtained from it a spark of 10½ inches, with a battery of four elements. The largest spark yet obtained in Europe has been 4½ inches. The original machine is the result of the researches of Faraday, Henry, and Fizian, and gives a current of high intensity, with a quantity immensely greater than can be obtained from the electrical machine.

Professor D. Olmsted, of Yale College, *on the Electrical Hypothesis of the Aurora Borealis.* It is his opinion that the aurora is cosmical in in its nature, or derived from matter connected with the planets: (1.) Because of its great extent, often extending far above our atmosphere; (2.) The same phenomena occurs simultaneously in places widely different in longitude; (3.) From the velocity of its motion; (4.) From its periodicity, especially its secular periodicity; which he regarded as well established. He thinks it may have a revolution round the sun, and is perhaps connected with the zodiacal light. He thought that the arguments of those who ascribe an electrial origin to the phenomenon, could not all stand the test of inquiry. One reason for disputing them is found in the fact that the aurora prevails in those latitudes where the amount of electricity is least.

Professor A. D. Bache *on the Heights of the Tides of the Atlantic Coast of the United States.* A comparison of the heights of the tides along the coast, leads him to form three groups of figures corresponding with three great bays on the coast, the tides being least at the outermost extremities of the bays and greatest at the heads. The first of these bays, which he calls the "Southern," extends from Cape Florida (where the tide is 1·3 feet in height), to Cape Hatteras (2 feet), with Port Royal (7 feet) as the head. The second extends from Cape Hatteras to Nantucket (1·2 feet), with Sandy Hook (about 5 feet) as the head. The third includes Massachusetts Bay and the Bay of Fundy, or from Nantucket to Cape Sable (8 feet), with its vertex at the head of the Bay of Fundy (36 feet).

Professor Stephen Alexander *upon the Special Harmonies in the Distances and Periods of the Planets.* Too perfect a symmetry in nature is not to be expected. He proposed a modification of Laplace's nebular hypothesis, by supposing the centre of the mass to radiate heat more rapidly than the periphery, so that the Sun separated first, then Mercury, then Venus, &c. He went on to show that the distances and periods of the planets follow certain arithmetic laws of geometrical progression more accurately than they follow Bode's analogy or Pierce's suggestion of the phyllotactic series. This he attempted to show by a careful arithmetical comparison of all the statistics of the actual systems of the Sun, Jupiter, and Saturn, with the arithmetical results of his hypothesis. In addition he showed that his hypothesis led at once to Kirkwood's Analogy (presented at the Cambridge meeting of the Association), both in its general truth and special features. The Moon and the Earth also bore testimony with peculiar force and relation to the truth of his hypothesis. The inclination of the planets to their orbits in its general law and its exceptions flows from the same fertile thought. The Zodiacal light, as observed by Mr Jones, is also explained in the same manner, and even the cosmical origin of the *Aurora Borealis* is made plausible by it. Professor Alexander thought that at all events the number of numerical coincidences here brought forward made it probable that we had in his theory a glimpse of the plan by which the great Disposer of all things had arrayed the worlds.

Dr J. H. Gibbon, of the United States Mint, read the third of his historical papers *on the Diverse Weights employed in Modern Coinage.* The avoirdupois ounce and pound was originally used in Babylon, a city of merchants; thence carried to Phœnicia and to Spain, whence it came to England and America. The Hebrew shekel was at least very nearly half an ounce avoirdupois, and it seems to be the oldest weight known in human history. According to tradition it weighed 320 grains of barley. The purchase by Abraham of the cave of Machpelah is distinctly stated to be a cash transaction, to be settled by the payment of a certain weight of silver of a certain fineness "current with the merchants." The sum paid to Joseph's brethren by the Egyptians, in payment for the boy, was twenty of silver; doubtless twenty avoirdupois pounds. Wherever the precious metals are mentioned by Hebrew writers, we are to understand the numbers as referring to avoirdupois weights. These weights came into use in England in the 14th century. A conventional avoirdupois ounce was adopted by the United States from Spain as the value of our moneyed unit. The word *dollar* and the word *coin* are both probably of Greek origin, *eidolon* and *eikon*, each signifying an image or idol, and the first coins having been stamped with the images of gods or kings. The "images" which Rachel stole from her father, and hid in the camel's furniture, were probably coins—not of Hebrew coinage, but of neighbouring *idol*atrous nations. The law requiring a hireling to be paid at sundown, and Jonah's paying his fare to Tarshish, indicate the use of small coins among the Hebrews. Our arbitrary unit does not agree exactly with any ancient or modern weight. The ancient Tyrian ounce contained 438 grains of very great fineness; while our modern dollar contains only 384 grains of inferior silver, as coined in halves. It was originally 416 grains. The half shekel of the Hebrew was, therefore, worth 63 cents of our modern American money. A Troy ounce is 480 grains, taking all the grains the same. The sterling—that is, Easterling—ounce was still different. Thus, all our modern weights and coinage are the remains and vestiges of ancient civilizations, now lost. In ancient times coinage was common in every colony and city. The ancient laws of Deuteronomy are similar to those Newton sought to establish when master of the English Mint, and declare emphatically that justice and accuracy in dealings are favourable to longevity.

Professor STEPHEN ALEXANDER, of Princeton College, gave some further statistics and inquiries with respect to *the Forms and Magnitudes of the Asteroids.*

GEORGE M. DEXTER, Esq. of Boston, read a paper *On Weights and Measures.* He spoke of the various attempts which have been made to establish a uniformity of weights and measures. A new system should embrace not only uniformity, but also a standard to which reference may be made without a scientific test, which shall so compare with the present system as to be easily learned; it should be labour-saving and computed by decimals. He reviewed the character and origin of the measures now in use in this country. He proposed to make an inch (one tenth of our present foot) the standard of measure, and an ounce, derived from the inch, the standard of weight.

Mr FRANKLIN B. HOUGH of Albany, gave a *Sketch of a Plan for Reducing Observations upon Periodical Phenomena to a Series of Mean Dates,* and set forth the advantages of this method for developing the laws of climate. He divides the State in which observations are to be made into sections according to the physical condition of the country, and "at the same sime preserving county lines so far as may be." The plan will give a knowledge of the relative forwardness of particular seasons; the comparative climate of different sections, also showing what crops are adapted to each, and enabling us to obtain the average time of the flowering of plants, or the breeding of birds, and thus to determine the laws of their species. In illustration of the first point, he read a table comparing the occurrence of similar phenomena in the various districts of New York, in 1842 and 1838, showing that the former season was earlier than the latter, by an average of 18⅘ days.

Dr J. H. GIBSON read his *Fourth Essay; on the Metrical System of France, and its adaptation to the Commerce, Coinage, and Science of the World,* beginning with a sketch of the ancient coinage and the fluctuations of value, and gradual debasement of pennies until they became pure copper. The great variety of measures and weights in the different provinces of France almost exceeded enumeration. The diversities of measures in Germany were equally perplexing. Dr Gibbon gave a sketch of the origin of measures from the personal diversions of kings and princes, or even barons and ladies. He then reviewed the history of attempts to find a perfect measure of length in nature (as the day is a perfect measure of time). The system of France is the only scale thoroughly scientific. Our American coinage is not even consistent with itself. A silver dollar contains 27 grains more than two half dollars. An agreement between mints of different countries would be valuable in furnishing bullion to the silversmiths, and thus save our coinage from destruction. Ten millions per annum of coins are melted up in America. The decimal system of France has been adopted in several continental mints. The adoption in mints would lead to its adoption in weights and measures. Weights and moneys were originally equivalent, and both should be kept rigidly invariable by the general governments of the world. In introducing the French weights and measures in Bavaria, not the slightest compulsion was necessary. By simply having all public business done with the new weights, the people were drawn into them by their convenience.

water, by the burying of islands of upland in the salt marsh, and by its effect upon the efficiency of mills located in tide water. He estimates that this subsidence of the coast, amounts to two feet in a century.

T. Sterry Hunt read a paper containing *General Considerations on the Metamorphism of the Sedimentary Rocks.* He contended that a dry heat, producing fusion of the sediments, cannot be admitted to explain the changes which they have been found to have undergone, from the fact that such a temperature is incompatible with the existence of alkaline silicates and graphite in the limestone. The influence of hot water alone is equally inadmissible, for the silica being dissolved by water before it could act upon the bases, we should find the quartzites rendered vitreous and crystalline. He regards the changes as having been produced by the action of small amounts of carbonate of soda in aqueous solution, forming with the quartz, silicate of soda, which is afterward decomposed by the carbonate of lime, the yielding silicates of these bases reproducing the alkali soda. A portion of the alkali is, however, always fixed, and rendered insoluble in the process, so that with a limited portion of soda, the action is at last exhausted. These reactions, resulting in the production of silicates of lime, magnesia, &c., take place even at 212° Fahr., and the intervention of alumina gives rise to garnet, chlorite and epidote. The absence of iron from some felspathic and quartzose sediments, and its accumulation as beds of iron ore, he regards as effected by the agency of organic matters, which reduce the iron to protoxide, and render it soluble in water, which afterward deposits it as oxide or carbonate. The same process produced the fire clays and ironstones of the coal period, and is now operating in bogs and marshes. In this way we have beds of argillaceous and felspethic materials freed from iron.

Mr Berthold Sieman *upon the Parthenogenesis of Animals and Plants,* showed that cases of parthenogensis occur in some lower orders of animals, and is quite frequent among plants.

Sir William E. Logan, of Montreal, read a letter from Sir Roderick Murchison, *on the Place in the Geological Series, of the Great Crystalline Rocks in the North Highlands of Scotland.* In a late visit thither, Sir Roderick had confirmed his previous opinion that they are anterior to the Old Red Sandstone, and are of the Lower Silurian age.

Sir William Logan *on the Probable Subdivision of the Laurentian Series of Canadian Rocks.* The Canadian rocks are now divided into two grand divisions,—those with much lime, and those without. His paper was intended to show, from observations which have been made upon a limestone deposit which emerges in two bands at Grenville, L. C., and which he has traced some eighty miles, the probability that the first grand division may be sub-divided, and that the Labradorite may be found to extend from one end of the British provinces to the other, and, with the rocks associated with it, may be marked upon the map, and receive some new appellation.

Professor Dana exhibited some trilobites collected at Keeseville, N. Y. These are very small, but of great importance, being the first that have been found in the Potsdam sandstone, within the State of New York. The discovery of other shells with them seemed to prove that the Potsdam sandstone had an extensive fauna.

Professor Hall considered these trilobites the same, generically, with those of Bohemia, and specifically with those of Scandinavia.

Professor DANIEL WILSON, of Toronto, read a paper *on the supposed Uniformity of Cranial Type throughout all Varieties of the American Race.* In common with other investigators, he had at first accepted the theory of Dr Morton implicitly, but in the course of his investigations, and especially in an examination of twenty-eight skulls of Canadian aborigines, he had been led to place less confidence in Dr Morton's generalization. Dr Morton had stated that there is a recognizable uniformity of type among all the ante-Columbian inhabitants of this continent, with the Esquimaux. Professor Wilson, however, had found several skulls near Detroit, which approximated to the elongated Esquimaux type; and he believed that the distinction between the Esquimaux and the other former inhabitants, was less in the form of the cranium than in the configuration of the face. Several other gentlemen expressed the opinion that further investigation would tend to weaken rather than confirm the opinions of Dr Morton.

Professor DAWSON *on the Newer Pliocene Fossils of the St Lawrence Valley.* He did not find reason to think there was any very great difference in climate between their time and the present. They were found at different heights. Here on Montreal Island there was a deposit of them about 470 feet above the level of the sea. The place where they are found seems to have been a sea-beach, formed at a time when a strait ran between the two elevations of Montreal Mountain. Another locality of them has been discovered by Sir William Logan at Beaufort, where they are but about 400 feet above the sea-level. The limits of the sea at these times must have been very different from the present. If the levels of the shores were the same, the sea on whose beach the bed first spoken of was deposited must have extended up as far as Niagara Falls on the west. On the north, owing to the greater height of the intervening hills, it could only have connected with the Arctic Sea by the eastward as at present. Then we have these shells again at about 120 feet above the sea-level. Here we have beds of sand resting upon beds of stiff clay, on the surface of which is a sandy clay which is full of these shells, and this sandy clay is pretty clearly a littoral deposit, but could not have been contemporaneous with the shore first spoken of, from the great difference of level, and as soon as we get into the stiff clay, we lose almost all traces of these shore shells. Hence Professor Dawson inferred that the clay was deposited in deep water, probably when the sea stood at the level of the first bed, and was then elevated so as to receive the latter bed of shells, thus decreasing the extent of the sea from the great extent which it had at first.*

Dr A. A. GOULD, of Boston, was inclined to doubt the correctness of Sir Charles Lyell's theory, that the fossil shells of Beaufort indicate a much colder climate than now exists.

Mr C. WHITTLESEY *on the Fluctuations of Level in the American*

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* The American Editor of this Journal has shown (see Proceedings of American Association for 1849,) that the newer pliocene fossils found in Montreal Island, at an elevation of 470 feet above the tide level, were not originally deposited there, but were swept thither from a much lower level at the epoch of the *Second Drift*.—(Edit.)

Lakes.—He had had access to observations on the stage of the water at Cleveland, Buffalo, Oswego, Detroit, Rochester, and the Sault Ste. Marie Canal. From these he found three kinds of fluctuations; a general rise and fall extending through long periods, but without regularity; a general fluctuation occurring within each year, without reference to the stage of the water; and an irregular oscillation of from a few inches to a few feet, continuing from one to twenty-four hours.

The general rise and fall, no doubt proceeds from the changes of the seasons, the lakes being merely the reservoirs of the drainage of large areas. On short streams, rains produce high water in a short time, but on the Mississippi, the Orinoco, the Ganges, &c., it is months before the rise is perceived in the lower parts of the river, and the same result would be perceived in the St Lawrence, the outlet of all the lakes, which receives its waters from as far as the Mesabi range and the prairies of Wisconsin, especially in consequence of the checks which the water meets with at the various lakes.

As to the changes in the height of the water from one year to another, the average in Lake Erie from the highest in 1838 to the lowest in 1819 is about seven feet. On Lakes Huron and Michigan, there are evidences of a change of twelve feet. The fluctuation on Lake Superior since 1845 has been about three feet. In Lake Ontario, from 1838 to 1854, the greatest range was four feet nine inches. The yearly changes are not more than a foot and a-half. The highest water does not come at the same time of the year in all the lakes, but occurs in Lake Superior in September or October, and the lowest water in February or March; while in Erie, June is the high water month, the low water months being the same, and nearly the same with Ontario. They are lower in the winter, because their streams bring in less water then. The late climate of Lake Superior tends to make its high water later, though low water is about the same. The thaw on Lake Superior comes some four or six weeks behind that of Erie, and its greater size and smaller streams require more time to fill it up.

The irregular fluctuations have been noticed ever since the times of the Jesuit explorers. They have been attributed to sudden atmospheric changes. Mr Whittlesey had noticed none of more than two feet high in stormy weather, and a foot and a-half in calm weather, during ten years' exploration on Lake Superior, and two years' residence at Eagle River. He found the average of a complete oscillation about four and a-half minutes, the vertical range of the wave being about four inches, and coming in a line parallel to the shore. The pulsations are less regular in stormy than in windy weather; but they occur in all conditions of the atmosphere, and at all times of the day. They are not confined to the great lakes, but are also in the smaller lakes of New York, and perhaps might be found in the ocean. Mr Whittlesey found no connection between them and any barometric change, but was inclined to look to electro-magnetic influences. If there is such a barometric wave, it would, he thought, be due to causes seated on the land.

Mr T. STERRY HUNT, of Montreal, *on the Parallelism between the Laurentian and Silurian Metamorphic Rocks.* He traced first a similarity between the felspathic rocks of the two series; the talcs of the silurian series are represented by the Rensellærite of the Laurentian.

A. C. **Ramsay**, Esq., of the Geological Survey of Great Britain, described the physical breaks and the breaks in the succession of life in the British rocks. He exhibited a chart to show the successive fossiliferous strata of Great Britain, marked with the number of genera and species of fossils found in each, as well as the number of genera and species which pass from one series to the next above. He thought that the extinction of the animal and vegetable species of fossils was owing to similar physical changes to those which are constantly working at present.

Dr J. H. **Gibbon**, of the U. S. Mint, Charlotte, N. C., next read an essay *on Troy Weight*, giving a historical sketch of the weight and coinage of earliest nations, the origin of sterling money and the Troy weight of Great Britain, and of the present use of the latter weight. The design of the paper was to show the advisability of moving toward the final adoption of a uniform system of weights, measures, and coins. The U. S. Mints introduced several changes in the English systems, but while some of these changes have simplified the matter, others have not, and our own coinage, measures, and weights are in a state of confusion. It is highly desirable that a uniform system should be devised and made common at least to the coinage of Great Britain, her dependencies, and the United States.

Mr E. W. **Hilgard**, *on the Quantitative Assay of Chromium by the Blowpipe.* The object of quantitative blowpipe assays is mainly a practical one; they are to enable the explorer in the field to determine not only the kind but the absolute value of ores on the spot, so as to guide him in further investigations. To serve this purpose the process of determination must be both short and capable of execution by means of such compendious apparatus as that composing the admirable micro-laboratory, Plattner's blowpipe chest. The processes themselves, as devised by Plattner, are mostly conducted in the dry way by the aid of the blowpipe. The metals are obtained in the shape of beads, easily cleansed and weighed, thus avoiding the tedious operations of precipitation and filtration, so often recurring in the usual wet way of analysis Processes of this kind have been described by Plattner for gold. silver, lead, copper, tin, bismuth, cobalt, and nickel. With metals difficultly fusible and reducible, which cannot be obtained in beads, we are obliged to resort to mixed methods, partially employing the wet way. Chromium is one of these metals; it has now become of considerable practical importance, yet its quantitative determination has been thus far confined to the laboratory. The first step is the fusion of the ore or substance with alkalies, preferably nitre, by which chromium is so readily separated from most bases. This is done in a small platinum crucible over the spirit lamp. When lead or analogous metals are present, silica must be added to the flux, to prevent an inversion of the process, when, subsequently, the mass is dissolved in water. This solution, when filtered, will contain most of the acid elements present in the ore, silica and manganic acid having been eliminated by nitrate of ammonia and alcohol respectively, previous to filtration. Were the chromic acid to be precipitated by one of the metallic salts usually employed, the precipitate would be contaminated with the other elements referred to; besides, such a precipitation is never complete until after several hours. A ready process of separation from almost all the acid substances, is in the evaporation to dryness of the filtrate with an excess of sulphuric acid and bisulphate of potash, and subsequent heating until all the chromium has passed into the insoluble modification of chrome alum. After this, most of the acid elements will still remain soluble in an acid solution, while the double sulphate of chromium and potash may be collected on a filter; being subsequently ignited, a residue remains, consisting of the sulphate of potash and chromic oxide in the same proportions as in the original salt; being weighed, therefore, the amount of oxide is found by a simple calculation.

The evaporation is carried on simultaneously with the first filtration in a little evaporator of platinum covered with a glass, framed so as to allow of keeping the fluid violently boiling without loss. The powdery precipitate of the chromo-potassic salt, which clogs the filter, is involved in a precipitate of chlorosulphide of mercury formed in the acid solution, and is washed by a solution of corrosive sublimate. The ignition is performed in a Plattner's charcoal furnace, before the blowpipe, in a platinum crucible. When all precautions are observed, results rarely varying one-tenth per cent. may be arrived at in the space of one and a half to two hours.

Professor A. C. Ramsay, of London, read a paper written by J. W. Salter, Fellow of the Geological Society of London, in which he describes a newly discovered genus of fossil coral, or Polyzoa, which is allied to the Graptolites, and which he calls *Graptora.*

Professor Hitchcock, of Amherst, *on the Age and Dip of the Connecticut River Sandstones, and the intercalation of the Associated Trap.* The identification of fossil foot-prints, especially those of insects, has led him to conclude that the middle series of these sandstones is of the Jurassic period. There are three series—the underlying heavy sandstone; a middle series of shales and micaceous sandstones above the trap; and a coarse conglomerate or breccia over all. The trap is intercalated between two layers of sandstone, of which the dip of the upper is less than that of the lower, and how the trap can occur in such a position, without breaks or faults in the sandstone, is a remarkable fact, difficult to explain.

Professor Swallow, Geologist of Missouri, exhibited *a Geological Map of that State.* Below the carboniferous rocks they had used the nomenclature of the New York Survey—above they had had some difficulty. The state is, to speak generally, divided by a narrow line of carboniferous limestone from north-east to south-west. To the north-west of this lie the coal measures; to the south-east Lower Silurian. Scattered mountains of trap lie to the south-east of St Louis; in the south-east corner the New Madrid district of alluvium stretches forty miles by sixty, and a narrow lane of alluvial deposits lies along the line of the Missouri and Mississippi Rivers. The coal measures are 1500 feet thick, with from eight to ten beds of workable coal. The beds of limestone in the coal measures are thick and numerous. He found coal all along the Missouri line, and he thought that the coal measures extended westward a hundred miles or more in Kansas. They had a patch of a hundred thousand square miles of coal-measures in Missouri, Nebraska, Kansas, Illinois, and Iowa.

Dr T. C. Hilgard *on the Structure of the Head in Vertebrata.* Oken has considered the skull as consisting of four modified vertebræ; Carus as consisting of six. Dr Hilgard shows, by a critical examination and comparison of the skulls of men with those of other mammals, and also birds and fishes, that the skull consists of five modified vertebræ, thus bringing it into one of the phyllotactic numbers. An embryological examination of the development of the brain shows also in that organ a phyllotactic generation in position as well as in the number five. In a second part of the same paper he shows that the embryonic development of the whole body is in accordance with phyllotactic law, both in number and order of position. Many of the anatomical facts elicited in these investigations are extremely curious. He has found, for instance, in the heads of fishes, bones similar in form to the wings of birds and the paws of rabbits; and he shows that this resemblance is not accidental, but actual, in relation to the vertebræ.

SCIENTIFIC INTELLIGENCE.

ZOOLOGY.

On the Anatomy and Physiology of the Spongiadæ. By J. S. Bowerbank, F.R.S.—The arrangement of the *Spongiadæ* by Lamarck, based entirely on external form, is wholly inadequate for the discrimination of species. The classification adopted by Drs Fleming, Grant, and Johnston, dependent more especially on the chemical constituents of those bodies, is far too limited to be applied to generic characters. The author has, therefore, for this purpose rejected both systems, and has retained the latter one for forming primary divisions only, and he purposes founding the generic characters principally on the organic structure and mode of arrangement of the skeleton, in accordance with the practice so generally adopted by naturalists with regard to many of the higher classes of animals. *Tethea*, *Geodia*, *Dysidea*, and a few others, are the only well-defined genera that have yet been established; while others, such as *Halichondria*, even in the narrow circle of the list of British species, contain at least ten distinct modes of arrangement of the skeleton, each of which is constant and well-defined in its character.

It is not intended to propose the rejection of any of the well-established genera of preceding authorities, but to confine each genus strictly within the bounds indicated by the peculiar mode of structure of the skeleton which exists in that species of sponge which is the oldest-established and best-known-type of the genus, and to refer all others that may distinctly differ from that type to new genera founded on structural principles.

It is proposed to characterize the elementary tissues in the following order:—1. Spicula. 2. Keratode or horny substance. 3. Membranous tissues. 4. Fibrous tissues. 5. Cellular tissues. 6. Sarcode.

And, in the second place, to treat of the organization and physiology in the following order:—1. The skeleton. 2. The sarcadous system. 3. The interstitial canals. 4. The intermarginal cavities. 5. The dermal membrane. 6. The pores. 7. The oscula. 8. Inhalation and exhalation. 9. Nutrition. 10. Cilia and ciliary action. 11. Reproduction, gemmules, &c.

And to conclude with observations on the generic characters.

The author then proceeds to describe the spicula, which he states are essentially different in character from the fibres of the sponge; although the latter may be equally siliceous with the former. However closely the spicula may be brought into contract with each other, or with siliceous fibre, they appear never to unite or anastomose; while the fibre, whether siliceous or keratose, always anastomoses when it comes in contact with other parts of its own body or with those of its own species. A detailed description is given of the origin and progressive development of these organs, from which it is inferred that they are the homologues of the bones in the higher classes of animals, and that the forms they assume are always of an organic type, never crystalline or angular; and the same forms of spicula are found composed of either silex or carbonate of lime, demonstrating the fact that the deposits of earthy matter are influenced by the laws of animal organization only, and never by those of inorganic or crystalline arrangement.

Each species of sponge has, not one form of spiculum only, equally dispersed throughout its whole substance, but, on the contrary, separate parts have their appropriate forms; and thus we find that there are often three, four, or even more forms of spicula in the same individual. The author therefore, in describing them, proposes to treat of these organs in the following order:—1. Spicula of the skeleton. 2. Connecting spicula. 3. Defensive spicula. 4. Spicula of the membranes. 5. Spicula of the sarcode. 6. Spicula of the gemmules.

1. The spicula of the skeleton in the siliceous sponges are usually simple, elongate in form, slightly curved, and are occasionally more or less furnished with spines. They are either irregularly matted together, collected in fasciculi, or dispersed within or upon the keratose fibres of which the skeleton is to a great extent composed. All these elongate forms of spicula are subject to extreme variety of length. In some species they maintain a great degree of uniformity, while in others they vary to a very considerable extent, according to the necessities arising from the mode of the construction of the skeleton.

2. The connecting spicula are not necessarily a part of the skeleton; they are a subsidiary portion of it under especial circumstances, in a few genera only, as *Geodia*, *Pachymatisma*, and other sponges which have a thick crustaceous surface, which the spicula serve to support and retain in due connection with the mass of the animal beneath. The normal form of these spicula is very different from that of the general mass of those of the skeleton, and they are much more complex and varied in their structure. They usually have a long, stout, cylindrical or attenuating shaft terminating either acutely or hemispherically at the base, while the apex is divided into three equiangular radii, which assume in different species a considerable amount of variety as regards form and direction. The triradiate apices are usually cemented firmly to the inner surface of the crustular coat of the sponge; while the stout and elongated shaft is intermingled with, and firmly cemented by keratode to the general mass of the skeleton.

3. The defensive spicula are divisible into two classes: those of the exterior, and those of the interior of the sponge. They are neither of them necessarily present in every species, nor are they confined to particular genera, but occur occasionally, and in certain species of various genera, apparently as the necessities of the animal may render their presence requisite. Their office is evidently to defend the sponge from the attacks of predacious animals. They are projected for about half or two-thirds of their length at various angles from the surface of the sponge, or they are based on the fibre of the skeleton, and are projected at about right angles into its interstitial cavities.

4. The spicula of the membranes are of two distinct classes. The office of the first of these is to strengthen and support those delicate tissues, and to communicate to them a certain amount of tension. The forms are few in number, and their structure comparatively simple. The office of the second class is that of assisting in the retention of the sarcode on the interstitial and other structures. They are usually minute in size, and often very complicated in form.

5. Spicula of the sarcode. The numerous and beautiful tribe of stellate spicula appear to be devoted to connect and give substance to the gelatinoid sarcode which so abundantly covers the whole of the interior membranous structures of the sponges in which they occur. They are often exceedingly minute, and are occasionally remarkably complex and beautiful in structure, and we frequently find more than one form imbedded in the sarcode of the same sponge.

6. The spicula appropriated to the gemmules of sponges occur in various modes of disposition. First, they are imbedded irregularly in an external envelope of the gemmule, or on the surface of the gemmule itself at right angles to lines radiating from its centre. Secondly, they are arranged symmetrically in the crust of the gemmule parallel to lines radiating from its centre. Thirdly, they are disposed in fasciculi in the substance of the gemmule from the centre to the circumference.—(*Proceedings Royal Society.*)

Researches on the Intimate Structure of the Brain, Human and Comparative.—Part. I. *The Medulla Oblongata.* By J. Lockhart Clarke, Esq., F.R.S.—The medulla oblongata, as described in this memoir, extends from the first cervical nerve to the lower border of the Pons Varolii. Of its elementary parts, the author first traces the *arciform fibres*, which may be divided into a superficial and a deep layer. Those of the superficial layer may in turn be divided into three sets. The connections of these are first followed out in detail; the fibres of the deep layer are described further on. In all mammalia these fibres are very distinct, but less intricate than in man. They may be found also in birds, reptiles, and fishes.

The *anterior pyramids* are found to be composed of *four* orders of fibres:—

1. *Decussating fibres* from the *lateral columns*, forming their chief bulk.
2. *Decussating fibres* from the *posterior columns* and *posterior grey substance*, chiefly at the upper part.
3. *Decussating fibres* from the *anterior gray substance.*
4. *Non*-decussating fibres of the *anterior columns*, separate on their outer side, and on their inner side incorporated with those which form the decussation.

In mammalia generally the decussating fibres are much less numerous than in man. In birds there is an evident but feeble decussation.

Of the *corpora olivaria* it is remarked, that they are to be found not only in all mammalia, but also to a certain extent in birds. In man, the surface of each olivary body consists of two layers of fibres—transverse and longitudinal; the former in part belong to the arciform system,—the latter are continuous with the antero-lateral column. A broad transverse commissure unites the two bodies. The *corpus dentatum* is a convoluted vesicular sac, consisting of nucleating cells of small and rather uniform size, from $\frac{1}{1300}$th to $\frac{1}{1700}$th of an inch in diameter, but varying in shape, and many of them sending out processes,—some one, others two, three, or more. The connection of the fibres with the convolutions of the sac is extremely complicated, and not to be made intelligible without the aid of diagrams. It may be stated, however, that the fibres which are confined to the cavity of the sac, with some others, take their origin from the cells.

In mammalia generally the olivary bodies are nearly concealed behind the paramids, and vary in their appearance at the surface in different animals. The vesicular sac, or *corpus dentatum*, is thrown into only a few comparatively large convolutions. On the outer side of each olivary body, and separated from it by a groove which lodges the hypoglossal nerve, is another vesicular column, not hitherto described by anatomists, and of which the analogue is found in the human medulla.

As the fibres of the lateral columns cross over to the anterior pyramids. the posterior cornua sink as it were forwards, while their terminal tufts —*the gelatinous substance*, gradually increasing in bulk, reach the surface, and form the grey tubercles of Rolando. At the same time, and close to the posterior median fissure, the gray substance is raised into a small conical projection, from which a network of blood-vessels and fibres extends backwards into the posterior pyramid. Within the projection, and amongst the network, cells are developed, which are circular, pyriform, or irregular in shape, and give off one process or several. Further outwards, another, but larger projection, and another network, extend backwards into the restiform body, containing cells of the same character, but of superior size. These additional productions may be called respectively the *post-pyramidal* and *restiform* ganglia.

As the medulla ascends, the *root* of the *posterior cornu* and the *whole* of the *anterior cornu* are gradually resolved or spread out into a beautiful and complicated network, containing a multitude of variously-shaped cells, which communicate and surround with their processes the longitudinal bundles of the white columns enclosed in the meshes. The post-pyramidal and restiform ganglia continue to increase in size, as do also the terminal tufts of the posterior cornua, which, like the former, are traversed by an extension of the network, and interspersed with cells. At the lower extremity of the olivary bodies, the decussation of the anterior pyramids, although still considerable, is very much reduced; for while its fibres derived from the lateral columns have been gradually decreasing in number, those which proceed from the posterior columns and posterior gray substance have been increasing, though not in the same proportion. These latter fibres may be traced backwards from the decussation chiefly to the restiform body and its ganglion, in which they wander in various directions, crossing each other, and becoming longitudinal.

In front, and at the side of the central canal, a new group or column of cells begins to make its appearance,—the nucleus of the hypoglossal nerve; and *behind* and on each side of the canal appears the nucleus of the spinal-accessory nerve, which is connected with its fellow of the opposite side, at the bottom of the posterior fissure, by a transverse band of fibres,—the continuation of the posterior commissure of the medulla spinalis. Of the spinal-accessory nerve, some of the upper roots proceed to their own nucleus, while others bend forwards into the hypoglossal nucleus, and in part join its fibres, to decussate through the raphè with those of the opposite nerve. The *vagus* nerve arises from a continuation of the spinal-accessory nucleus, and, on its way outwards, passes through the terminal tufts of the posterior cornu, or the so-called *gelatinous substance*. The vagal and spinal accessory vesicular nuclei or columns, after appearing in the fourth ventricle, and diverging so as to expose the hypoglossal nucleus, sink abruptly beneath a new mass of vesicular substance which makes its appearance on each side of the ventricle. This is the auditory ganglion. It commences by a point on the outer side of the vagal nucleus, with which it is intimately connected, and is developed from the inner part of the post-pyramidal ganglion. Its cells are various in shape, and as they are developed from the inner part of the posterior pyramid, the outer side of the latter undergoes a remarkable change of structure, and becomes the chief origin of the *anterior division* of the auditory nerve, which in its course outwards runs between the restiform body and the *gelatinous substance* or posterior cornu. The posterior division of the nerve winds transversely inwards over the restiform body to reach the auditory ganglion.

Intimately connected with the auditory nerves and ganglia is the structure which, in animals, is called the trapezium, and which the author has found to inclose a remarkable vesicular sac resembling that of the olivary bodies. The analogue of the trapezium exists in the human medulla.

The facial nerve, or portio dura of the seventh, after passing through the trapezium, proceeds transversely inwards to the *fasciculus teres*, which contains a mass or column of stellate cells, and through which it spreads, exchanging fibres or forming loops with the sixth or *abducens* nerve, which arises from the same nucleus. The glossopharyngeal nerve has more than one origin. It passes out in several bundles through the gelatinous substance or posterior cornu, *in* which it forms a plexus with longitudinal fasciculi of fibres which may be traced upwards to the larger root of the fifth nerve.

The connecting fibres between the anterior and posterior portions of the medulla are very numerous and complicated. For convenience of description, they may be divided into two parts,—superficial and deep. The superficial are the superior layers of the arciform system, and arise from the restiform body and its ganglion; the deep fibres, more or less blended with the first, arise from the remains of the post-pyramidal and the restiform ganglia. Together they form a complicated network, or plexus, interspersed with innumerable and variously shaped cells, which frequently communicate around the longitudinal bundles of the lateral columns, through which and the olivary body the fibres of the plexus proceed forwards and inwards to the raphè, where they decussate with those of the opposite side, and become continuous with the arciform fibres which were traced to the raphè round the anterior pyramids as the superficial set. The raphè, therefore, is the seat of a very complicated decussation between the posterior halves of the medulla, on the one hand; and on the other, between each of these and the olivary body of the opposite side.—(*Proceedings of the Royal Society.*)

On the Anatomy of Tridacna. By JOHN DENIS MACDONALD, Assistant-Surgeon, R.N.—The author first explains the peculiar position which the animal of *Tridacna* occupies in its shell, in which it differs from bivalves in general. He then describes the mantle and its borders, the membranous interpallial septum, the respiratory and wide pedal openings communicating with the interpallial space, the two pairs of branchiæ, the mouth with the anterior and posterior lip and the four oral palps, the foot, the extensive cloacal cavity with its subdivisions, and the circular contractile cloacal orifice opening on the dorsal surface. He next gives an account of the form and arrangement of the alimentary canal, and its relations to the liver and large ovary; and describes a large viscus situated in the space between the ovary, the adductor muscle, the base of the foot and the pericardium, divided into a central and two lateral portions, and secreting a dark brown liquid loaded with fatty matter. This body he thinks may be connected with the secretion of the byssus, but, at the same time, remarks that it may be homologous with the organ of Bojanus. Lastly, the anatomy of the heart and great arteries is given, and is in substance as follows.

On cutting through the floor of the cloaca, the pericardium is laid open, and in it is seen the large, rather square-shaped ventricle, with a capacious but thin-walled auricle opening into it on either side, through an orifice guarded by semilunar valves. From the thick-walled ventricle, a short tube conducts into a conical dilatation or *bulbus arteriosus*, with muscular walls having its base included in the pericardium, and giving rise near its narrow end to the anterior and posterior pallial arteries; whilst a visceral artery passes from the ventricle to the ovary and adjacent parts. As in other bivalves, the intestine, before its termination, passes through the heart: in coming through the pericardium, surrounded by the membrane, it forms a short round pedicle which joins the fore part of the ventricle; it is then continued through the ventricle and bulbus arteriosus, and finally opens into the cloaca. The blood from the ventricle flows between the outer surface of the intestine and the inside of the sanguiferous channel; and that part of the intestine which traverses the bulbus arteriosus is closely surrounded with elongated membranous valvulæ, which arise from the anterior part of the chamber where the gut enters, and are fixed by a number of cordæ tendineæ to the posterior wall, where it makes its exit; a contrivance which permits the blood to pass between the rectum and the little valves, but prevents its reflux.—(*Proceedings of Royal Society of London.*) .

Fauna der Wirbelthiene Deuchlands und der angrenzenden Länder von Mitteleuropa. Erster Band. Naturgeschichte der Säugethiere. Von J. H. Blasius. 8vo. 1857.—The first volume of the above work containing the Mammalia, has just been published; it is an excellent Manual. The text, German, illustrated by numerous, well executed woodcuts, representing some of the smaller animals, but chiefly devoted to the skull and dentitions, and other details, such as the head and ears of the bats, &c. These are nearly all slightly enlarged, and give a very distinct idea of what are considered the specific distinctions. The second volume, said to be in the press, will be devoted to the birds; the third and last, to the reptiles and fishes.

Einhundert Tafeln colorirter Abildungen von Vogeleiren. Zur Fortpflanzungsgeschichte der Gesammten Vögel. Von Friedrich August Ludwig Thienemann. (4to completed). 1856.—This is the most extensive series of coloured figures of the eggs of birds that has yet been published. It is now completed as a first series, and contains good coloured representations of the eggs of *nine hundred species.*

Die parasiten der Chiroptern. Von Prof. Dr E. A. Kolenati. Dresden. 8vo, plates. 1857.—Descriptions of 69 species of internal and external parasites found on the Chieroptera.

BOTANY.

Vegetable Parthenogenesis.—The production of perfect germinating seeds in plants without the contact of pollen was noticed long ago by various vegetable physiologists, but the occurrence of this vegetable parthenogenesis was considered doubtful by subsequent authors, and the statements were attributed to imperfect observations. Of late, however, these statements of old authors have been confirmed by very careful examination of plants of *Cœlebogyne, Cannabis, and Mercurialis;* and Dr Radlkofer has recently published a paper, in which he states, from very accurate experiments and dissections, that he is satisfied that true parthenogenesis does take place in plants. To Mr Smith at Kew the botanical world is indebted for the first observation on the plants of Cœlebogyne, and these plants have been made the subject of experiment by Radlkofer.

Economical Use of Oak and other kinds of Timber.—M. Kreuter, in reporting on the timber shown at the late Paris exhibition, states, that France requires annually for the Imperial navy 1,120,000 cubic feet of oak timber, and for the commercial navy 1,400,000 cubic feet. Britain requires five times as much, and America still more. There was at the Exhibition the model of a ship at present being built in Britain under the direction of M. Brunel, and intended for the Australian trade, which requires 644,000 cubic feet of solid timber for its construction. The timber consumed for railway sleepers is now enormous. A sleeper measures 3 cubic feet, and one mile of single rails requires about 8000 sleepers, which last on an average five years. Hence 1600 of these sleepers require changing annually. For 100 miles this will amount to 160,000.

Turmeric.—M. Milne, botanist to the United States Herald, and formerly of the Botanic Garden, Edinburgh, in giving an account of an excursion into the interior of Naviti Levue, the principal of the Feejee Islands, writes as follows:—"In passing along, we came to a place where we found several women manufacturing turmeric (from the rhizome of a species of *Curcuma*), and upon the sides of the river were large quantities of refuse. In a small house close to the water there were two pits, 18 inches deep, lined with Bavaria leaves, and made water-tight; also a number of posts set into the ground, having rough bark, to be used as graters. When a quantity of the rhizome is grated, it is committed to the pits, where it remains for some time, and is afterwards carried to a canoe, then strained through a close-worked basket lined with fern leaves, and then put into short bamboos, where it remains for four nights and four days. It is then fit for use, and proves one of the principal articles of food, being made into puddings, mixed with grated sugar-cane. It is used also for covering children after birth, and for painting the bodies of women previous to strangulation.—(*Hooker's Kew Journal.*)

Mode of Drying Succulent Plants.—M. Motley, in writing from Borneo, states, that he believes he has hit on the right way of drying succulent plants, and such as are apt to come to pieces. He had previously tried hot water, but that made the specimens mould; then a hot iron, but that was tedious, and it spoiled the flower; pricking the leaves with a penknife or fork was of use, but the specimens looked unsightly after it; and chloride of calcium was too troublesome. He now puts the plants into a large bottle of weak spirit for one night. This kills them, and an endosmose goes on in the tissues, which breaks them up, and makes them dry as quickly as other plants.—(*Hooker's Kew Journal.*)

Pteris aquilina, as an Esculent Vegetable.—The rhizome of this plant is used in the north of Europe to form a coarse kind of bread, in the same way as *Pteris esculenta*, a variety of it, is used in New Zealand. The rhizome is washed and peeled, scraped and formed into a pulp, all the slime being washed away. The pulp thus procured forms palatable bread. The very young fronds, completely blanched, may be used as a vegetable like asparagus.

Colouring Matter on Fronds of certain Ferns.—M. Prillieux has examined the colouring matter on the fronds of certain ferns belonging to the genus *Gymnogramma*. Some of these ferns have the under surface of their fronds of a pure white, while others are of a sulphur yellow. The colour is produced by a matter deposited on the surface of the frond. This matter is easily removed by the fingers, and is of a fatty nature. When held on paper it stains it like grease. It is dissolved in alcohol, oil of turpentine, and in oil. The alcoholic solution on evaporation yields a crystalline matter, which has not been examined chemically as yet. On examining the colouring matter with the microscope, it was found to consist of a mass of interlaced filaments. These filamentous bodies are produced apparently by capitate glandular hairs which are seen covered with minute threads. On removing these threads by alcohol, the hairs are shown of a balloon-like form, with an elongated neck,—the rounded upper portion formed of a single cellule, the stalk or neck of one or two cellules. In *Gymnogramma chrysophylla farinosa*, and *dealbata*, the summit of the hair is spherical; in *G. calomelanos* and *hybrida* it has a more ovate form. The terminal cell of the hairs is perforated with very minute holes, through which it appears the secreted matter passes from the interior in the form of filaments. In *G. hybrida* the punctuations or holes are about $\frac{1}{700}$th of a millimetre.—(*L'Institut.*)

Mannite.—The mannite which is developed on the surface of many marine algæ when they are dried in the air is considered by M. Phipson as the result of a particular kind of fermentation, by which the mucilage of the leaves is deoxydised. He does not consider it as a secretion of the living plant.

Ophioglossum vulgatum.—M. Schrietzlein states that the Ophioglossum vulgatum possesses a horizontal rhizome, on which are developed several buds at the distance of 2 or 3 inches, which give rise to stems and leaves.

Cuscuta.—M. Schrietzlein has observed at the end of the embyro of Cuscuta, two germinal leaves distinctly visible. The plant is therefore not acotyledonous, as has been generally supposed.

Spilanthes oleracea.—In the capitules of this plant M. Schrietzlein has noticed florets with five styles, and others with three or four, a remarkable anomaly in the order Compositæ.

Action of Pollen in the Development of Fruit.—M. Maudin, Assistant Naturalist in the Museum of Natural History of Paris, has made experiments on four Cucurbitaceæ, viz., *Ecbolium elaterium*, *Cucurbita pepo*, *Cucurbita melanosperma*, and *Cucumis abyssinicus*, with the view of ascertaining whether or not the action of the pollen on the stigma is necessary for the development of fruit containing either no seeds or abortive ones. He found that when these plants were placed in circumstances where to all appearance the pollen could not come into contact with the stigma, the fruit was developed in a much less complete manner than in ordinary circumstances; and that when the plants were fertilized by the pollen of different species, they developed their fruits, but for the most part without having seeds with an embryo. He concludes that the pollen acts therefore not only on the ovules but also on the ovaries and fruit.

Hygrometric Filaments or Hairs in Capsules of Orchids.—M. Prillieux states that the internal surface of the valve of the capsule of *Pleurothallis obtusifolia* is covered with filaments or hairs which are disposed in an irregular manner amidst the seeds. After the dehiscence of the capsules the filaments appear free—having no adhesion to the walls. The filaments are formed of long fibres, arranged in pairs. These filamentous hairs are very hygrometric, and when breathed upon show marked movements. They probably assist in scattering the seeds in the same way as elaters do. The same sort of hygrometric hairs exist in the capsules of *Fernandezia acuta*, *Leptotes bicolor*, *Vanda multiflora*, *Angræcum fragrans*, *pusillum*, *&c.*—(*L'Institut.*)

Juice of Chinese Green.—Decaisine finds that the plants whence the Chinese derive their Indigo *Lokao*, a substance known in commerce as Chinese green, are species of Rhamnus, which he describes under the names of *Rhamnus chlorophorus* and *Rhamnus utilis*.

Canella.—M. Grisebach, from an examination of Caribbean plants in the collection of Dr Duchassaing of Guadeloupe, has shown that the genus *Canella* is allied to the genus *Tasmannia*, and ought to be placed among the *Magnoliàceæ*. This seems to explain the reason why it has been confounded with Drimys.—(*L'Institut.*)

Alpine Vegetation of the Colony of Victoria.—In order now to accomplish the examination of the Alpine Flora on the Eastern frontiers, I started for the Coborras Mountains, the most prominent points of the great dividing range within the borders of this colony. Not only these mountains, but also the greater part of the interjacent plains or plateaux, are of a truly alpine or subalpine nature, ranging in elevation from 5000 to 6000 feet above the level of the ocean. As some of the highest sources of the Murray and of the Gipps Land rivers rise in this vicinity, the supply of water is plentiful. The valleys are either covered with spongy mosses (chiefly *Sphagnum*), which become transformed into peat, or they produce nutritious grasses, some luxuriant enough to recommend their introduction into countries of the arctic zone —(*Hierochloe antarctica, H. submutica, Agrostis frigida, nivalis*, &c.) The vegetation of the Coborras Mountains does neither fully agree with that of Mount Buller, examined last year, nor with the Alpine Flora of Van Diemen's Land; although the following series of its plants may indicate its partial identity with both:—*Ranunculus pimpinellifolius, R. scapiger, Geranium brevicaule, Acacia bossiæoides, Hovea gelida, Oxylobium alpestre, Anisotome glacialis, Didiscus humilis, Celmisia astelifolia, Eurybia megalophylla, Brachycome nivalis, B. multicaulis, Ctenosperma alpinum, Ozothamnus Hookeri, O. cinereus, Antennaria nubigena, Senecio pectinatus, Goodenia cordifolia, Gaultheria hispida, Leucopogon obtusatus, Lissanthe montana, Richea dracophylla, Prostanthera rotundifolia, Euphrasia alpina, Gentiana Diemensis, G. montana, Grevillea australis, Pimelea gracilis, Podocarpus montana, Exocarpus humifusa, Juncus falcatus, Restio australis, Oreobolus Pumilio, Lomaria alpina, Polytrichum dendroides*, &c. Here all these plants are alpine, notwithstanding some of them descend in Tasmannia to the low land. But to those already known I had the gratification of adding several new species, probably peculiar to the Alpine Flora of Australia, namely:—*Phebalium phylicoides, Asterolasia trymalioides, Mniarum singuliflorum, Bossiæa distichoclada, Centella cuneifolia, Anisotome simplicifolia, Eurybia alpicola, Ozothamnus planifolius, Gnaphalium alpigenum, Hierochloe submutica, Glyceria Hookeriana, Agrostis gelida*, &c.—(*Report of Dr Mueller, the Government Botanist.*)

Woods of the Colony of Victoria.—The woods stand in this regard prominent in importance. The Blue Gum tree of Van Diemen's Land (*Eucalyptus globulus*) is found abundantly in some of the forest districts, principally of the south, and is already so well known for its colossal size, as to render it superfluous to quote the statements made of its vast dimensions. Of the circumference of the stem instances are on record, by which this tree ranks only second to the famous Boabob from the Senegal. The experiments instituted in Van Diemen's Land have shown "that its elasticity and strength exceed generally those of all woods hitherto tested;" "it is equal in durability to oak, and superior to it in size;" and therefore highly esteemed for ship-building. Other *Eucalypti* likewise claim attention, on account of the beauty and durability of their wood, in consequence of which qualities one of them, from the south-eastern frontiers, received there the name of the Mahogany tree. The wood of *Callistemon salignus*, although the tree is seldom of large dimensions, stands here, perhaps, unrivalled for hardness. The fragrant Myall wood, so well adapted for delicate ornamental work, is obtained from *Acacia homalophylla*, and some allied species in the Mallee desert. The well-known Blackwood (*Acacia melanoxylon*), in some localities called Lightwood, attains in the Fern-tree gullies an enormous size, and yields a splendid material for furniture, at once most substantial, and capable of a high polish, being also recommended for the finishing work of vessels. The Myrtle tree of Sealer's Cove and the Snowy river (*Acmena floribunda*) is also remarkable for its straight growth and its excellent wood. The Australian evergreen beech (*Fagus Cunninghami*) forms a noble tree, sometimes more than 100 feet high, of which the wood takes a beautiful polish. Omitting such kinds as are more generally known, I may yet mention as useful, chiefly for ornamental work, the Sassafras wood (from *Atherosperma moschatum*), the Lomatia-wood (from *Lomatia polymorpha*), that of the Tolosa-tree (*Pittosporum bicolor*), the Musk-wood (from *Eurybia argophylla*), the Iron-wood (from *Notelæa ligustrina*), that of the Oil-fruit tree (*Elæocarpus cyaneus*), the Zieria-wood (from *Zieria arborescens*), that of the Heath-tree (*Monotoca elliptica*), and of the Australian Mulberry-tree (*Pseudomorus Australasica*). Samples of those kinds, which are met with on Wilson's Promontory, have been procured for the Paris Exhibition, and may give some additional proof that we possess woods here for any purpose, with the exception perhaps of such as are fit for larger ships' masts.—(*Report of Dr Mueller, the Government Botanist.*)

Flora of Oregon and California contrasted with that of the Eastern Side of America.—A proper discussion of the relations existing between the vegetation of the eastern and western sides of the continent would demand a notice of the remarkable *absence* west of the Rocky Mountains of a great variety of genera, tribes, and even orders, which are eminently characteristic of the flora of the Eastern States. For example, Oregon and California have no *Magnoliaceæ*, *Anonaceæ*, *Menispermaceæ*, nor *Cabombaceæ*, no *Nymphæa*, although a Nuphar is plentiful, no *Tilia* or Bass-wood, no *Camelliaceæ*, no indigenous Grape-vines, except one in California, only one *Polygala*, no Locust or other Leguminous trees, no Passion-flowers, no *Hydrangea*, no *Hamamelaceæ*, few *Rubiaceæ*, no *Vernoniaceæ*, and very few *Eupatoriaceæ*, very few *Asters* and *Solidagos* (but the numerous *Compositæ* tend strongly to *Helenieæ*, and are mostly of genera which are neither Eastern, North American, nor European in type), no *Lobelia*, no true Huckleberries (*Gaylussacia*) nor *Vaccinia* of the Blueberry type (the section *Cyanococcus*), no *Clethra*, and few *Andromedeæ*, no *Aquifoliaceæ*, *Ebenaceæ*, nor *Sapotaceæ*; no true *Bignoniaceæ*, no *Acanthaceæ*, nor Gerardias, no *Sabbatia*, no *Dirca* nor *Podostemon*, solitary representatives here of their respective orders; no *Empetraceæ*, no Elms (although there is a *Celtis*), no Mulberry, no Walnuts, Hickories, or other *Juglandaceæ*, nor a Beech, Hornbeam, nor Ironwood; no true *Araceæ*, *Hydrocharidaceæ*, *Hæmodoraceæ*, *Burmanniaceæ*, *Dioscoreaceæ*, *Pontederaceæ*, *Commelinaceæ*, *Xyridaceæ*, or *Eriocaulonaceæ*; few *Orchidaceæ*, and still fewer *Cyperaceæ*, none of the latter, either *Rhynchosporeæ* or *Scleriеæ*; and Paniceous and Andropogineous Grasses are altogether absent.

How these failures are made up by a large increase of peculiar generic and specific forms in a few families, I will not stop to illustrate. But it is worth noticing that, while our eastern flora possess so many orders which are not represented in the western, no order represented in Oregon or California is wanting in the flora of our Northern States, unless *Hydroleaceæ* and *Garryaceæ* be counted as independent orders; and both of these occur in the Atlantic states south of our geographical limits. —(*Asa Gray, in Silliman's Journal*, May 1857.)

The Prominent Characteristics of the Flora of the Northern United States.—To answer the question as to what are the leading characteristics of the vegetation of the Northern United States, taken as a whole, we should have to consider, first: What are the more remarkable peculiarities of our flora, as discovered by the instructed botanist, with the whole field systematically displayed to his mental view; and secondly, what are the plants or the forms of vegetation which, by their abundance or their prominence, impart to our flora its dominant features. The first is a matter of deduction from a variety of facts, many of which would never arrest the attention of the casual observer: the second relates to points which would most attract the notice of the passing botanical traveller or the ordinary observer. The answer to the former no less than to the latter inquiry, would depend upon the point of view. To the traveller from the Southern States, or from the great plains of the West, the novel features of our vegetation are those which it has in common with Europe. To the European visitor the striking peculiarities are those which we share with the southern part of the country, and these would increase in prominence as he proceeded southward and westward. And, in forming his idea of a flora, the botanist naturally, if not inevitably, takes that of Europe as his standard of comparison.

In comparing, as the botanist naturally would, our flora with that of Northern and Western Europe, the following would appear to be leading characteristics.

1. Our comparative richness in ordinal types;—our flora having, as already remarked (vol. xxii. p. 216), 26 orders which are absent from that of Europe; while the latter, exclusive of the Mediterranean basin, has only seven orders which are wanting here.

2. The prevalent subtropical character of our extra European orders;—which has been already referred to, and which will be manifest to the botanist inspecting the list of such orders given in a former article (vol. xxii. p. 215).

3. Our richness in species of woody plants, and especially of trees; as already alluded to (p. 84). This will strikingly appear from a comparison of our flora with an equivalent European one—with the German flora, for example. In Koch's *Flora Germanica* (excluding the Adriatic region), I count 60 indigenous species of trees, belonging to 27 genera, and comprised in fourteen orders. In our own *Flora of the Northern United States*, adopting the same estimate as to what constitutes a tree, I count 132 trees, in 56 genera, and belonging to 25 orders; as follows:—

Magnoliaceæ,	2	genera, and	6	species of trees.
Anonaceæ,	1	„	1	„
Tiliaceæ,	1	„	2	„
Camelliaceæ,	1	„	1	„
Anacardiaceæ,	1	„	1	„
Sapindaceæ,	3	„	8	„
Leguminosæ,	6	„	7	„
Rosaceæ,	4	„	15	„
Hamamelaceæ,	1	„	1	„
Araliaceæ,	1	„	1	„
Cornaceæ,	2	„	4	„
Caprifoliaceæ,	1	„	1	„
Ericaceæ,	2	„	2	„
Aquifoliaceæ,	1	„	1	„
Ebenaceæ,	1	„	1	„
Sapotaceæ,	2	„	1	„
Oleaceæ,	3	„	8	„
Lauraceæ,	2	„	2	„
Urticaceæ,	4	„	8	„
Platanaceæ,	1	„	1	„
Juglandaceæ,	2	„	9	„
Cupuliferæ,	5	„	21	„
Betulaceæ,	1	„	5	„
Salicaceæ,	2	„	7	„
Coniferæ,	7	„	18	„

The only natural order containing trees in the German flora and not in ours is the *Rhamnaceæ;* the only order in which the German flora exceeds ours in arboreous genera is that of *Betulaceæ* (which comes from our not counting any of our Alders as trees); the only order in which the German flora has more species of trees than ours is that of the *Salicaceæ* (10 to 7), we counting but one truly arboreous indigenous Willow. On the other hand, our flora surpasses the German, not only in the twelve additional orders (one of which is represented by nine species and another by six), but also in having a greater number of species in ten out of the thirteen orders common to the two countries, and of genera likewise in all but three of them. That is, we possess of

Sapindaceæ (including Hippocastanaceæ and Aceraceæ),	2	more genera, and	3	more species of trees.
Leguminosæ,	5	„	6	„
Rosaceæ,	0	„	2	„
Cornaceæ,	1	„	3	„
Ericaceæ,	1	„	1	„
Oleaceæ,	2	„	6	„
Urticaceæ,	2	„	5	„
Cupuliferæ,	0	„	11	„
Betulaceæ,	0 (—1)	„	3	„
Coniferæ,	3	„	10	„

4. Our flora, it may be seen, accordingly predominates in its species of Pine, Fir, Oak, Birch, Elm, Ash, arboreous as well as shrubby *Cornaceæ, Cratægi,* and of arboreous *Leguminosæ;* and its characteristic trees are the *Taxodium*, the Overcup, Willow and Chesnut-Oaks, the Hickories and Walnuts, the Plane-tree and two *Sapotaceæ,* which barely reach us from the South, the Persimmon, the Gum-trees (both *Nyssa* and *Liquidambar*), the Common and Honey Locusts, *Cladrastis*, and the Kentucky Coffee-tree, the Negundo, and three species of Buckeye, the Sumac, the Loblolly Bay of our south-eastern border, the Papaw-tree, the Tulip-tree, and our five species of Magnolia. We might have added *Zanthoxylum*, but no Prickly Ash fairly forms a tree within our geographical limits.

5. Our flora is equally rich in shrubs, of a great variety of families, especially in those which make an undergrowth in forests; and, among them, in *Vaccineæ*, *Andromedeæ*, and *Rhodoreæ*, while it has no *Arbuteæ* rising above the surface of the ground, and no *Ericeæ* or Heaths at all.

6. It is also rich in *Compositæ*, especially Helianthoid *Compositæ*, *Eupatorinæ*, Asters, and Solidagoes, in the latter genera outnumbering any other region; but it is poor in *Anthemideæ*, true *Senecioneæ*, and in *Cynareæ*, and especially so in *Cychoraceæ.*

7. It has an unusual number of *Cyperaceæ*, which is owing partly to the remarkable number of extra-European genera, and partly to the number of species of *Cyperus*, *Rhynchospora*, and *Carex*.

8. From the position of *Rosaceæ* on the list of the larger orders, our flora would be supposed to be unusually rich in that order also; but this result happens in consequence of our remarkable comparative poverty in *Cruciferæ*, *Umbelliferæ*, *Labiatæ*, and *Caryophyllaceæ*. Other orders in which our flora is much deficient, as compared with Europe, are *Boraginaceæ*, *Campanulaceæ*, *Liliaceæ* in the larger sense, and *Iridaceæ*, *Crassulaceæ*, *Chenopodiaceæ*, *Primulaceæ* and *Geraniaceæ*. Those in which we are correspondingly rich are *Asclepiadaceæ*, *Polemoniaceæ*, *Smilaceæ*, *Melanthaceæ*, *Araliaceæ*, and *Onagraceæ*.

9. To present the elements of the 26 orders represented in our flora, but wanting in that of Europe, and in which characteristic features are necessarily comprised, would still further extend an article already inconveniently protracted. The botanist can readily gather the needful details respecting them, and respecting our extra-European genera generally, from the data given in a former article.

As regards the plants most striking and important in the physiognomy of our vegetation, the first rank is undoubtedly held by the trees of social growth; and of these the principal are *Coniferæ*. The characteristic tree of the proper Northern States is, therefore, *Pinus Strobus*. This, the tallest and once the most plentiful of our trees, when the country lay in all the wildness of nature, must have given the dominant feature to a great part of the landscape. White Pines may probably be distinguished by their port and aspect from a greater distance than any other of our forest trees, except perhaps the *Taxodium* of our Southern "Cypress" swamps, and the long-leaved Pine which so strikingly marks a belt of low and barren country stretching from the south-eastern borders of Virginia to the Gulf of Mexico and the Mississippi.

Pinus Tæda, near our southern limits, and, more northward, *P. rigida* and the other Pitch Pines, give a predominant feature to the "pine-barrens" of the Northern States.

Our Arbor Vitæ (*Thuja occidentalis*), of intensely social growth, is the physiognomic tree of our cold swamps at the North, and of Canada. Large tracts of cold and poor marshy land at the north, and on the mountains, are occupied with the well-marked Balsam Fir, or, where less damp, with the more sombre and stiff Black Spruce, or with the closely related White Spruce; the latter, however, only along our northern frontier. *Abies Fraseri* replaces the common Balsam Fir in the Alleghanies south of Pennsylvania, and has just the same aspect. Hemlock Spruce woods (*Abies canadensis*) cover hill-sides and sharp ridges of a light and thin soil, where water never stands, throughout the northern part of the country, with a truly characteristic forest-growth. Larch or "Tamarack" swamps are strongly marked in aspect, but are never large.

No other species of forest trees that I know monopolize the ground in so marked a manner, and impress their single features upon a tract of country. The Beech woods of elevated tracts, and the Sugar Maple in richer and lower grounds, make the nearest approach to it; but ordinarily our woods of deciduous trees consist of a mixture of several species, in which different kinds predominate according to the situation. In enumerating, as I have done farther back, the trees most characteristic of our three principal districts, I have mentioned those which more than any other give character to our arboreous vegetation. As trees which possess marked peculiarity, and which may be known from far, I barely mention the common American Elm of our intervales, the Button-wood or *Platanus* on the banks of rivers and streams, the Sugar Maple, the various Hickories, the Black Walnut, and several Oaks, the White and the Paper Birch, conspicuous from the ghastly white bark of their trunks, as well as by their light and handsome foliage, the Sassafras, the Cucumber-tree, the Tulip-tree, the Honey Locust with its remarkably light and feathery foliage, and the *Gymnocladus* or Kentucky Coffee-tree, with its thick and stout branchlets, and its remarkably decompound foliage, rendered the more striking in aspect by the oblique or almost vertical position which the leaflets generally assume.

Of trees conspicuous in blossom, *Cornus Florida*, the two Umbrella-leaved Magnolias, the Locust, the *Cladrastis*, the Red-Bud, and the Crab-Apple, hold the first place, and the Umbrella-trees with their rose-coloured cones are equally conspicuous in fruit. The Loblolly-Bay, *Rhododendron maximum*, and the *Chionanthus* or Fringe-tree, are equally showy, but they are generally shrubs rather than trees.

Considering our great variety of trees and shrubs, there is a remarkable absence of broad-leaved evergreens. The American Holly is our only tree of the sort of considerable size, and that is not a common one. Of large shrubs or small trees, *Rhododendron maximum* and *Kalmia lati-*

folia—our "Laurels"—are our principal and truly characteristic evergreens, as they are among the most social of our woody plants.

The herbaceous plants which most strike the eye are of course the *Compositæ*, especially towards the close of summer, when golden Solidagoes, and purple, blue, and white Asters, are everywhere conspicuous. Of vernal flowers—peculiarly delightful to us after a winter which destroys all herbaceous vegetation—the most common species which strike the eye over the whole country (in their appropriate stations) are *Caltha palustris*, *Aquilegia canadensis*, *Anemone nemorosa*, with *Thalictrum anemonoides*, *Sanguinaria canadensis*, *Saxifraga virginiensis*, *Viola cucullata*, *sagittata*, or one or two other stemless Violets, *Claytonia*, one or the other species, *Oldenlandia* (*Houstonia*) *cærulea*, *Senecio aureus*. *Smilacina bifolia*, *Erythronium americanum*, *Uvularia sessilifolia*, and, a little later, *Geranium maculatum*.

The part which introduced-plants take in our flora, with some kindred topics, must be considered in a future article.—(*Asa Gray*, *in Silliman's Journal*, May 1857.)

On the Mode of Formation of Cannel Coal. By J. S. NEWBERRY.—1st, Cannel coals always exhibit a tendency to assume the foliated structure of slates and shales,—a structure which they must have derived from aqueous deposition. They are frequently found shading into bituminous shale, into which they are converted, simply by accessions of earthy matter. Bituminous shale and cannel coal may, therefore, be considered as the same substance in different degrees of purity; that is, carbonaceous paste, deposited from aqueous suspension with different admixtures of earthy matter. The carbonaceous matter in bituminous shale, as in cannel, exhibits a preponderance of volatile matter over fixed carbon, and the gases furnished by it contain a larger proportion of the more volatile hydro-carbons, and possess a higher illuminating power than those derived from ordinary bituminous coal.

2d, The chemical composition of cannel coal—so rich in volatile ingredients—and its homogeneity, are such as would naturally follow the decomposition of vegetable matter while constantly submerged. Plants when deprived of their vegetative life, and exposed to the action of the air, are slowly decomposed by the process of decay; a process which, unattended by the sensible phenomena, heat and light, is however really a combustion, and consists in the union of oxygen with their hydrogen to form water, with their carbon to form carbonic acid, and of their carbon and hydrogen to form carburetted hydrogen, &c. When vegetable matter is covered with wet earth or clay, these changes are both modified and retarded, and an intermediate state, that of bituminization, is assumed by a portion of the organic matter. Under water the changes terminating in decay go on still more slowly, and a larger portion of the vegetable tissue becomes bituminized. The process of bituminization in such circumstances consists in the oxidation of a small portion of carbon,—which escapes as carbonic acid,—of hydrogen to form water, the union of carbon and hydrogen to form carburetted hydrogen and other hydro-carbons, and the combination and removal of a portion of the alkaline carbonates, of nitrogen, &c., all of which go to make up the loss, which is relatively small. The residuary hydrogen and oxygen unite with a portion of the carbon to form bitumen, which closely resembles, physically and chemically, the resins produced by the vital functions of many plants. This bitumen unites mechanically with the uncombined or fixed carbon, the remaining alkalies and inorganic matter, to form coal. It is evident, that the more ready the access of oxygen to the carbonaceous matter during the process of bituminization, the larger proportion of the products of complete combustion will be mingled with those of this process; and the more perfectly the oxygen is excluded, the larger proportion of the more volatile (*i. e.* more oxidable) constituents of the wood will be retained. Of the conservative influence of water on vegetable matter we have evidence, not only in the great durability of wood when constantly submerged, but in coal itself. In all coal strata, except where the process of volatilization is complete, as plumbago and perfectly gasless anthracites, the work of decomposition is constantly going on. To this as to ordinary combustion, water is an extinguisher. Coal mines are commonly opened in America by penetrating the coal on some hill-side where it is not covered by water. In these circumstances a progressive change, both chemical and physical, is noticeable in the coal from its outcrop to the point where atmospheric influences cease to act. Near the surface it is friable, lustreless, and nearly destitute of gas, having much the appearance and character of decayed wood. As it is more deeply penetrated it becomes harder and more brilliant, and contains more volatile matter, till under water or a sufficient cover of incumbent rock, it is protected from the action of oxgyen. On the contrary, whenever the outcrop of a coal stratum is constantly covered with water, even though it have no other covering, it will be found hard and bright, and containing nearly its maximum quantity of volatile ingredients.

3d, The higher illuminating power of the gases of cannel coal is a natural consequence of the preservation of the more volatile constituents of wood, by its continued submersion in a hydrogenous liquid. It is also probable that the illuminating power of cannel gas is often somewhat increased by the animal matter which it contains. I have found remains of fishes in slaty cannel, surrounded by bitumen having in a high degree the characteristics of the bitumen of cannel. That a more resinous vegetation has given cannel this character is, I think, not probable. I have often found unchanged resins in common bituminous coal but never in cannel.

4th, The greater relative proportion of earthy matter in cannels would be a necessary result of the submersion of the vegetable matter in a fluid having a greater specific gravity than air, and, of course, greater power for the suspension and transportation of sediment. In the few instances known where the cannel is of equal purity with bituminous coal, we may I think discover evidences that the vegetable matter has been deposited in confined bodies of quiet water, entirely without currents, or, at least, receiving little or no surface drainage.

5th, The fossils contained in cannel coal are among the most significant indications of its aquatic origin. Fishes are found in cannel in abundance, scales, teeth, spines, coprolites, and entire individuals being, in some localities, so profusely scattered through its substance as to prove conclusively that they must have lived and died in great numbers in waters, at the bottom of which comminuted vegetable matter was accumulating as a carbonaceous paste with which their remains have mingled, and the whole, consolidated, has become a stratum of cannel. I have before me as I write, pieces of beautiful cannel from England, in which are impacted teeth of *Megalichthys*, scales of *Palæoniscus*, and many other forms of aquatic life. And in Ohio I have found fishes in large numbers in a thin stratum of cannel underlaying a thick seam of bituminous coal; which last contains none. Shells too are not unfrequently found imbedded in the middle of a stratum of cannel. The vegetable remains which I have observed in cannel are *Stigmariæ*,—roots and rootlets of trees which grew in the coal-marshes,—generally occurring in detached fragments—shapeless portions of the trunks of *Lepidodendra* with their markings nearly obliterated, *Lepidostrobi* reduced to their woody skeletons, fern fronds of which nothing but rachis and veins remain, all evidently macerated till only their most resistant tissues are left. Strata of ordinary bituminous coal usually consist of thin layers of brilliant bitumen alternating with others of bituminous shale or cannel. This arrangement I consider due to the variable quantity of water saturating and overflowing the coal-marshes: the cannel layers having been deposited during the prevalence of high water.

MISCELLANEOUS.

Ascent of Chimborazo.—The *Echo du Pacifique* of the 3d January, gives the following account of an ascent of Chimborazo, made on the 3d November 1856 by a French traveller, M. Jules Remy, accompanied by M. Brenchley, an English traveller.

"On the 23d June 1802, the illustrious Humboldt, accompanied by his friend Bonpland, made the first attempt to ascend Chimborazo. On account of a pointed rock, which presented an insurmountable barrier, they were unable to ascend above 5909 metres of the mountain, then regarded as the highest in the world, and which still occupies a principal place among the colossi of America.

"Thirty years later, on the 16th December 1831, M. Boussingault, after a long and skilful examination of the Cordillera of the equator, endeavoured to accomplish the ascent in which his predecessor had failed. He reached the enormous height of 6004 metres, that is to say, 95 metres higher than the others; but he was arrested by rocks as they had been, and could not get beyond this limit, which was then the most elevated point ever attained by man on mountains.

"The accounts of these famous travellers had deprived us of all hope of reaching a height so considerable, but, after having observed the snowy and rounded summit of Chimborazo from Guyaquil, we could not help thinking that it was accessible from some point or other. M. Brenchley and myself were thus led to form the design of attempting a third ascent.

"On the 21st July 1856, as we crossed the plateau of the Andes on our way to Quito, we halted at the foot of this stupendous mountain. We employed two days in studying its outlines from a distance, with the view of discovering any peculiar places on the surface of its gigantic dome which might afford us a passage.

"The route followed by M.M. Humboldt and Boussingault, seemed to us at first to be greatly the most easy and desirable on account of its regular declivity; but the barrier of rocks, which we readily distinguished, presented no outlet to the eye. When we had made nearly the entire circuit of this mighty mountain, and without success, we resumed our journey towards Quito, reserving the execution of our plan till we should be better fortified against the rigorous climate of the higher Cordilleras.

"After visiting Pichincha, Cotopaxi, and other giants of the Andes, we again found ourselves, on the 2d of November, at the foot of Chimborazo. We pitched our camp at a height of 4700 metres, a little below the line of perpetual snow, in a valley between Arenal and the point where the Riobamba route separates from that of Quito. We intended to spend the following day in collecting plants and hunting deer and birds, endeavouring, at the same time, to determine beforehand the places which might afford us the most easy access to the summit.

"We took up our quarters under a huge inclined rock, which afforded us sufficient protection against the north-west wind, but gave us no shelter in the event of rain. Rain had fallen in the afternoon. The weather cleared at night-fall, the sky became sprinkled with myriads of stars, and Chimborazo was delineated, in all its splendour, on the azure and sparkling vault of the firmament.

"On the morning of the 3d November, at five o'clock, when day had not yet dawned in the equinoctial regions, we left our camp in charge of our people, and departed on our exploring expedition, carrying with us a coffee-pot, two thermometers, a compass, matches, and tobacco. A steep hill, sandy and rough with pebbles, which separated us from the perpetual snow, occasioned us so much fatigue at our outset, that two of the natives who accompanied us became discouraged and turned back.

"When we had surmounted this hill, we descended on some soft sand to the bottom of a valley, which we followed, and from the extremity of which, we distinguished very clearly the summit of the mountain, entirely free from snow.

"After walking half an hour on the snow, vegetation suddenly ceased, and we saw no other living thing but two large partridges, and on the rocks a few lichens of the families Idiothalamus and Hymenothalamus. At this point of our ascent we collected some dry branches of chuquiragua, and made a bundle of them which we tied to our backs. We had still to scale an immense rock of trachyte, from the top of which the summit of Chimborazo appeared to us so near, that we thought we could reach it in half an hour.

"Our ascent was so rapid, that we were soon obliged, from fatigue, to make frequent stoppages to recover our breath. Thirst also began to be severely felt, and in order to moderate it, we almost always kept snow in our mouths. But we felt no symptoms of illness or any morbid affection, such as is spoken of by the majority of travellers who have ascended high mountains.

"After halting a few seconds, without even seating ourselves, we again started not only with renewed ardour, but even a kind of furious determination inspired by so near a view of the summit. It appeared evident to us, by this new instance confirming so many previous ones, that at these heights the atmospheric column is still sufficient to prevent any impediment to respiration, and that the shortness of breath and organic affections which are so generally complained of at considerable elevations, must be ascribed to some other cause.

"Always rapidly ascending, we now began to overlook the peaks of the Cordilleras, and to discover a distance furnished with immense valleys, when some light vapours, which at first appeared only like spiders webs on the sides of the mountains, soon began to detach themselves in the form of white flakes, stretching nearer and nearer to each other, till they at last arranged themselves like a girdle along the horizon.

"All of a sudden, about eight o'clock, this curtain enlarged itself, and approached Chimborazo; then in a few minutes, it mounted to us, thin at first, but becoming perceptibly more dense. We no longer could perceive the summit. We continued, however, to mount upwards, enticed by the hope of attaining our object much more easily than we had supposed on leaving our encampment.

"The fog continued to increase; we could not see twenty paces from us. At half-past nine, it had become so thick that it was almost as dark as night at the distance of a few metres. Confident of finding our footsteps again to guide our descent, we travelled on with additional stubbornness; but we had every moment to examine the compass, in order to avoid a precipice which we had left on our right before reaching the terminal depression by which we resolved to gain the summit.

"It seemed to us that the declivity became less steep, we breathed more freely, and walked with less effort. Some dull detonations began at intervals to be heard in the distance. At first we ascribed them to the explosions of Cotopaxi; but soon reverberating peals, such as are heard only in the vicinity of the equator, convinced us that thunder was rolling in the lower regions. A terrible storm was in preparation.

"In the fear that the hail or snow would efface the marks of our feet, and thereby expose us to the risk of losing ourselves in the descent, we determined, with regret, to halt for a while. We hastened to kindle our chuquiragua wood, in order to melt the snow in our coffee-pot. At ten o'clock, the thermometer which, at five feet above the snow, indicated 1·7, was plunged in boiling water where the mercury stood at 77·5.

"At five minutes past ten, our observations terminated, and we began to descend with giant strides in order to regain our encampment as speedily as possible. We arrived there in the midst of the thick fog about an hour after noon. The thunder rolled almost without interruption, the flashes of lightning describing dazzling zigzags around us, never seen elsewhere so distinctly defined except in pictures.

"About three o'clock, a fearful tempest of rain, hail, and wind assailed us under our rock. It continued throughout a part of the night with a fury which seemed as if it could never be allayed. We were literally lying in water. On the morrow, at day break, our eyes rested everywhere on a vast field of hail.

"Certain indications of another tempest made us abandon the idea of trying again the ascent of Chimborazo, which we henceforth regarded as quite impracticable. We made all haste to break up our camp and make for Guaranda, where we arrived about three o'clock, travelling through a cold and dense fog, which prevented us for that day admiring one of the most beautiful views in the world.

"When we calculated our observations, we were not a little surprised to find that we had reached the summit of Chimborazo without being aware of it. According to personal researches, made at first in the Archipelago of Hawaii, and afterwards repeated among the Cordilleras of the equator, the co-efficient of the sum of degrees or fractions of a degree in the centigrade thermometer, reckoning between the point to which the mercury rises when the instrument is immersed in boiling water, and the boiling point of water at the level of the sea, is found to be 290·8; that is to say, each degree below 100 indicates a difference of level equal to 290·8 metres, or about 29 metres for the tenth of a degree, hence the formula

$$x = (100 - B)\,(290{\cdot}8)$$

which gives us 6543 metres for the absolute vertical height we had reached on Chimborazo. This figure places us quite on the summit, the altitude of which, above the sea level, according to Humboldt's triangulations, is 6544 metres. But whatever degree of confidence may be conceded to our calculations, the unquestionable fact resulting from our ascent is, that the summit of Chimborazo is accessible!!

On the Early Stages of Inflammation. By JOSEPH LISTER, Esq., F.R.C.S., Eng. and Edin., Assistant Surgeon to the Royal Infirmary of Edinburgh. In this communication the author gives an account of an investigation with which he has been recently occupied, into the process of inflammation in the frog's foot.

The first section of the paper is devoted to the discussion of the aggregation of the corpuscles of the blood. It is shown by the author that the *rouleaux* "are simply the result of the disk-form of the corpuscles, together with a certain, though slight degree of adhesiveness, which retains them pretty firmly attached together when in the position most favourable for its operation, namely when flat surface is applied to flat surface, but otherwise allows them to slip very readily upon one another." The aggregating tendency of the red disks is thus regarded as a phenomenon similar in kind, though inferior in degree to the well-known adhesiveness of the white corpuscles. It is further shown, from numerous experiments, that the red corpuscles vary remarkably in adhesiveness, in consequence of changes in physical circumstances, or very slight chemical action.

Section II. is on the structure and functions of the blood-vessels.

Allusion is made to a paper by the author, which will shortly appear in the "Transactions of the Royal Society of Edinburgh," where he has recorded the observation, that in the smallest arteries of the web of the frog's foot, the middle coat is composed of muscular fibre cells wrapped spirally round the internal membrane. The parietes of the minute arteries are thus provided with a most efficient mechanism for diminution of calibre, and contrast in this respect very strikingly with the delicate nucleated membrane which constitutes the wall of a capillary. The functions of the two sets of vessels are described as being in harmony with these differences in structure; the arteries being specially characterized by contractility, while the capillaries exhibit only such changes of calibre as are explained by elasticity.

The thinness of the capillary wall is believed to favour the mutual interchanges between the blood and the tissues, but the consideration of some facts of physiology leads the author to the conclusion, that notwithstanding the distending force of the current of blood, the liquor sanguinis is not effused as a whole among the tissues in the state of health; and this is thought to imply that there subsists a mutual repulsion between the materials of the capillary wall and the elements of the liquor sanguinis, preventing the passage of the latter into the pores of the former, except in so far as they are attracted by the tissues for the purposes of nutrition.

The heart is believed by the author to be the sole cause of the circulation of the blood in the frog's foot, and it is proved experimentally that other sources of movement cannot have more than a very trivial influence, and that their cessation, supposing them to exist at all, does not give rise to arrest of the blood or accumulation of corpuscles in the capillaries.

Distinct evidences of muscularity and contractility have been detected in the veins of the frog's foot, but compared with the arteries, the veins show very little spontaneous contraction.

Regarding the influence of changes in arterial calibre upon the blood in the capillaries, the author is led to conclude that "the arteries regulate by their contractility the amount of blood transmitted in a given time through the capillaries, but neither full dilatation, extreme constriction, nor any intermediate state of the former, is capable *per se* of inducing accumulation of corpuscles in the latter."

The influence of the nervous system upon the arteries has formed the subject of a special experimental inquiry, the results of which are given in a supplement to the paper. It is there shown that the contractions of the arteries of the frog's web are regulated by a part of the spinal cord, the irritation of which induces complete constriction of the vessels, while its destruction is followed by permanent dilatation. Neither stimulation nor removal of the nervous centre for the arteries produces any perceptible change in the quality of the blood, as respects adhesiveness of its corpuscles or otherwise.

Section III., "on the effects of irritants upon the circulation in the frog's web," commences with an account of some experiments performed with tepid water applied for a brief period to the foot. This agent, which was selected as the mildest possible stimulant, produces in a very beautiful manner constriction of the arteries, followed by dilatation, with corresponding changes in the amount of blood transmitted through the capillaries, as explained at the close of Section II. When, however, such experiments were frequently repeated upon the same animal, and especially if the temperature of the water was more elevated, effects of a different kind began to show themselves; the corpuscles of the blood experiencing obstruction to their progress even while the arteries were fully dilated, and the vessels consequently in the state most favourable, so far as their calibre was concerned, for transmitting the current of blood. If the irritation was still continued, the minute vessels became choked with closely packed corpuscles.

Subsequent experiments, with a variety of other irritating agents, showed that the corpuscles, both red and white, were obstructed in their progress through the irritated part, in consequence of their tending to adhere in an abnormal degree to one another, and to the walls of the vessels. The effects upon the blood were always similar, although the means employed to produce irritation were exceedingly various, such as solutions of salts, mustard, essential oils, chloroform, heat, galvanic shock, mechanical violence, &c.

The irritant was generally so applied as to act only upon a small area of one of the webs, and it was found that the abnormal adhesiveness of the blood-corpuscles was in the first instance always precisely limited to the spot which had been thus acted on, though it frequently extended afterwards more or less to surrounding parts. At the same time the vessels of the irritated spot did not differ materially in calibre from those in its vicinity which participated in the arterial dilatation induced by the stimulus. The exact correspondence between the extent of the irritant application, and that of the effect upon the blood, showed that the latter must be due to direct action either upon the blood itself or the tissues of the web. That it was not the result of direct action upon the blood, was evident from the two following considerations. In the first place, most of the agents employed to cause irritation, when applied to freshly drawn blood, either had no effect upon the corpuscles, or destroyed instead of increasing their adhesiveness. Secondly, if employed so as to act mildly on the web, they induced an abnormal condition of the blood, short of actual stagnation though very apparent, namely, slow movement of numerous and adhesive corpuscles; and this state of things might last, although the time of operation of the irritant was often limited to a few seconds, or even a still briefer period. Long after all the blood which could possibly have been directly acted on had left the vessels of the part, successive fresh portions continued to experience precisely similar changes in passing through the irritated area. Hence the author considers the conclusion to be inevitable, "that the tissues, as distinguished from changes of calibre in the blood-vessels, are the primary seat of inflammation, and that the effects on the blood are secondary results of such derangement."

The remarkable fact discovered by Dr H. Weber of Giessen, but observed independently by the author, that accumulation of corpuscles occurs in the vessels of a part irritated, after circulation has been arrested by a tight ligature round the thigh, furnished the opportunity for careful comparison between the conditions of blood in healthy and irritated parts uncomplicated by the effects of rapid movement. A series of experiments conducted in this way confirmed the conclusion previously arrived at, that the accumulation of the blood-corpuscles was simply the result of their abnormal adhesiveness. At the same time these experiments brought out the remarkable fact, that mere quiescence of the blood does not give rise to aggregation of the red corpuscles within the vessels, unless the tissues are in an unhealthy condition in consequence of irritation. It further appeared that the corpuscles never exhibit greater adhesiveness within the vessels of an inflamed part, than do those of blood from a healthy part when drawn from the body. Also, the well-known adhesiveness of the white corpuscles within the vessel does not occur according to the author, unless some degree of irritation is present, and never exceeds that which is always seen in blood outside the body. Hence the inference is drawn, that the tissues of a healthy part exert an influence on the blood in their vicinity, by means of which the corpuscles, both red and white, are preserved free from adhesiveness; but that in an inflamed part this influence is more or less in abeyance.

This view has been confirmed by observations made on the wing of the bat.

Also the comparison of drops of blood from healthy and inflamed parts in the human object showed, that so soon as the blood was withdrawn from the vessels, the corpuscles of the former presented precisely the same degree of adhesiveness as those of the latter.

At the commencement of Section IV., "on the state of the tissues in inflammation," it is stated that "the conclusion arrived at in the latter part of the last Section, that blood flowing through an inflamed part behaves itself in the same way as when separated from the living body, naturally leads to us infer that the tissues of the inflamed part are in some degree approximated to the condition of dead matter, or, in other words, have suffered a diminution of power to discharge the offices peculiar to them as components of the healthy animal frame. This inference is strongly supported by considering what common effect is likely to be produced upon the tissues of the frog's web, by all the various agents known to cause inflammatory disturbance of the circulation." It is then pointed out that all these agents, though differing greatly in their nature, agree in their tendency to inflict a lesion on the part to which they are applied, and impair the functional activity of the tissues. "But strong as are the arguments thus obtained by inference, it would be very desirable to confirm them by direct observation of the tissues. It fortunately happens that the pigmentary system of the frog is a tissue which, from its peculiar form and colour, is very apparent to the eye, so that it is easy to trace the remarkably active functions with which it is endowed, and their modifications under the influence of irritation."

The author then mentions the circumstances which led him to notice that the dark pigment of the frog presents remarkable differences of appearance at different times in one and the same animal; each dark patch being sometimes of stellate figure with minutely ramifying rays, at other times in the form of a small rounded spot. These changes had been before observed by some German writers, who attributed the rounded form to contraction of the branching rays of a stellate cell. This, however, the author finds to be erroneous, and in a supplementary section "on the anatomy and physiology of the pigmentary system of the frog," shows that the cells never change in form or size, but that the pigment-granules which are suspended in a colourless fluid are capable of being, on the one hand, attracted by a central force into a small space in the body of the cell, and, on the other hand, dispersed by a repulsive power into the minutest recesses of the ramifying rays. Both concentration and diffusion of the pigment may take place with great rapidity, implying remarkable energy in the attractive and repulsive forces, both of which appear to reside in a nucleus. The supplementary section concludes with some remarks on the physiological importance of the actual observation of such attractions and repulsions in one of the animal tissues.

This paper continues with an account of an experimental investigation into the effects of irritants upon this function of the pigmentary system. Many experiments are related, all tending to support the general proposition, that "all agents, without any exception, which have the power of inducing accumulation of corpuscles and stagnation in the blood-vessels when applied to the web, paralyse at the same time the functions of the pigment-cells." It is also shown, from experiments upon amputated limbs free from blood, that this effect is independent of the state of the circulation. In cases of slight irritation in which the blood resumes, after a while, its natural characters (re-solution taking place), the paralysis of the pigment-cells is only temporary. "Thus the pigmentary system of the frog is a remarkably sensitive index of the condition of the affective tissue, and it is fortunate that its physical characters render it so easy to read its pointings. . . . . . The only other tissue of the frog's web, the functions of which can be observed by the eye, is that of the arterial muscular fibre cells," and it is found that arteries passing through an inflamed area lose their power of contraction within the limits of that area, whereas the same vessels may be often seen to contract in other parts of their course.

"Thus, direct observation of the structures of the frog's web which discharge functions apparent to the eye, furnishes unequivocal support to the inference derived from other considerations, that in inflammation the tissues of the part, the primary seat of the affection, are in a state of diminished functional activity."

The "conclusion" consists of an inquiry how far the views expressed in the paper regarding the early stages of inflammation harmonize with the more advanced phenomena of the morbid process and with other facts of pathology.—(*Proceedings of the Royal Society.*)

Gold in British Guiana.—Considerable excitement has been caused here by the arrival of a vessel from the Spanish Main, bringing letters, and also a copy of the *Guayana Gazette*, containing extraordinary reports of the discovery of a new gold field about 90 miles from Upata, where it will be recollected that about three or four years ago a large quantity of gold was taken from the river. One of these letters states that nearly all the clerks and labourers are leaving Cuidad Bolivar (Angostura) for the new mines which are at a place called Tupugun. The river steamers had been obliged to cease working, in consequence of all their hands having left and started for the gold fields. The average find is two ounces per day for each man; but there have been instances where much larger quantities have been taken; as much as twenty-four ounces having been found in between seven and eight hours; and two men who were working at the same time obtained forty-four ounces.

This gold field is said to be within the British territory of British Guiana, according to the line ran some years since by Sir Robert Schomburgh, by order of the British Government. The gold lies at a depth of between five and six feet from the surface. Large orders have been received here for pick-axes, shovels, and other implements for digging.—(*Port of Spain Gazette, May* 9, 1857.)

Magnetism.—Professor Hansteen of Christiania, the eminent Magnetical Philosopher, has presented a memoir to the Swedish Academy, proving, from his own observations, that the magnetic dip partakes of the daily, annual, and eleven-yearly periodic changes (the last coinciding with Schwabe's period of the solar spots), which have been already detected in the other magnetic elements. The same distinguished philosopher (who is now in his 73d year) expects soon to complete the reduction and publication of the magnetical results of his Siberian journey in the years 1828–30, which have been so long desired by the scientific world.

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